

FORM PTO-1300 (REV. 9-2001)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER <b>TSUK 0005</b>	
<b>TRANSMITTAL LETTER TO THE UNITED STATES          DESIGNATED/ELECTED OFFICE (DO/EO/US)          CONCERNING A FILING UNDER 35 U.S.C. 371</b>				U.S. APPLICATION NO. (if known, see 37 CFR 1.5) <b>10/018690</b>	
INTERNATIONAL APPLICATION NO. <b>PCT/JP00/04028</b>		INTERNATIONAL FILING DATE <b>21 June 2000</b>		PRIORITY DATE CLAIMED <b>24 June 1999</b>	
TITLE OF INVENTION <b>PHOTOSENSITIVE ELEMENT, PHOTORESISTIVE ELEMENT ROLL, PROCESS FOR THE PREPARATION OF RESIST PATTERN USING THE SAME, RESIST PATTERN, RESIST PATTERN LAMINATED SUBSTRATE, PROCESS FOR THE PREPARATION OF WIRING PATTERN AND WIRING PATTERN</b>					
APPLICANT(S) FOR DO/EO/US <b>CHIBA, Tatsuo and ICHIKAWA, Tatsuya</b>					
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:					
1. <input checked="" type="checkbox"/> This is a <b>FIRST</b> submission of items concerning a filing under 35 U.S.C. 371.					
2. <input type="checkbox"/> This is a <b>SECOND</b> or <b>SUBSEQUENT</b> submission of items concerning a filing under 35 U.S.C. 371.					
3. <input checked="" type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.					
4. <input type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (Article 31).					
5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2))					
a. <input type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau).					
b. <input checked="" type="checkbox"/> has been communicated by the International Bureau.					
c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US).					
6. <input type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).					
a. <input checked="" type="checkbox"/> is attached hereto. (including three (3) sheets of Formal Drawings - Figs. 1, 2A-B, 3, 4A-B and 5-8)					
b. <input type="checkbox"/> has been previously submitted under 35 U.S.C. 154(d)(4).					
7. <input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))					
a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau).					
b. <input type="checkbox"/> have been communicated by the International Bureau.					
c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired.					
d. <input checked="" type="checkbox"/> have not been made and will not be made.					
8. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).					
9. <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).					
10. <input type="checkbox"/> An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).					
<b>Items 11 to 20 below concern document(s) or information included:</b>					
11. <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98.					
12. <input checked="" type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.					
13. <input checked="" type="checkbox"/> A FIRST preliminary amendment.					
14. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment.					
15. <input type="checkbox"/> A substitute specification.					
16. <input type="checkbox"/> A change of power of attorney and/or address letter.					
17. <input type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.					
18. <input type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4).					
19. <input checked="" type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).					
20. <input checked="" type="checkbox"/> Other items or information:					
(A) Form PCT/RO/101 (5 pp.); (B) Form PCT/IB/301 & Annex; (C) Form PCT/IB/304; (D) Form PCT/ISA/210 - International Search Report (2 pp.) & English translation (2 pp.); with twelve (12) documents cited therein annexed; (E) Form PCT/IB/308; (F) Form PCT/IB/332; (G) Copy of Cover Pages of Publ. No. WO 00/79344 A1; and (H) Form PCT/PEA/409 - International Preliminary Examination Report (3 pp.).					

U.S. APPLICATION NO. <b>10/016890</b> INTERNATIONAL APPLICATION NO. PCT/JP00/04028	ATTORNEY'S DOCKET NUMBER TSUK 0005																			
21. <input checked="" type="checkbox"/> The following fees are submitted: <b>BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):</b> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO. .... <b>\$1040.00</b> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ..... <b>\$890.00</b> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... <b>\$740.00</b> International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... <b>\$710.00</b> International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) ..... <b>\$100.00</b> <b>ENTER APPROPRIATE BASIC FEE AMOUNT =</b>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2" style="text-align: left;">CALCULATIONS PTO USE ONLY</th> </tr> <tr> <td style="width: 60%;"></td> <td></td> </tr> <tr> <td>\$ 890.00</td> <td></td> </tr> <tr> <td>\$ -0-</td> <td></td> </tr> </table>	CALCULATIONS PTO USE ONLY				\$ 890.00		\$ -0-												
CALCULATIONS PTO USE ONLY																				
\$ 890.00																				
\$ -0-																				
Surcharge of \$130.00 for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492(e)). <input type="checkbox"/> 20 <input type="checkbox"/> 30	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 60%;">\$</td> <td></td> </tr> <tr> <td>\$ -0-</td> <td></td> </tr> </table>	\$		\$ -0-																
\$																				
\$ -0-																				
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 20%;">CLAIMS</th> <th style="width: 20%;">NUMBER FILED</th> <th style="width: 20%;">NUMBER EXTRA</th> <th style="width: 20%;">RATE</th> <th style="width: 20%;">\$</th> </tr> <tr> <td>Total claims</td> <td>40 - 20 =</td> <td>20</td> <td>x \$18.00</td> <td>\$ 360.00**</td> </tr> <tr> <td>Independent claims</td> <td>13 - 3 =</td> <td>10</td> <td>x \$84.00</td> <td>\$ 840.00</td> </tr> </table>	CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	\$	Total claims	40 - 20 =	20	x \$18.00	\$ 360.00**	Independent claims	13 - 3 =	10	x \$84.00	\$ 840.00	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 60%;">\$</td> <td></td> </tr> <tr> <td>\$ 840.00</td> <td></td> </tr> </table>	\$		\$ 840.00	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	\$																
Total claims	40 - 20 =	20	x \$18.00	\$ 360.00**																
Independent claims	13 - 3 =	10	x \$84.00	\$ 840.00																
\$																				
\$ 840.00																				
MULTIPLE DEPENDENT CLAIM(S) (if applicable) + \$280.00	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 60%;">\$</td> <td></td> </tr> <tr> <td>\$ -0- **</td> <td></td> </tr> </table>	\$		\$ -0- **																
\$																				
\$ -0- **																				
<b>TOTAL OF ABOVE CALCULATIONS =</b>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 60%;">\$</td> <td></td> </tr> <tr> <td>\$ 2090.00**</td> <td></td> </tr> </table>	\$		\$ 2090.00**																
\$																				
\$ 2090.00**																				
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 60%;">\$</td> <td></td> </tr> <tr> <td>+</td> <td></td> </tr> </table>	\$		+																
\$																				
+																				
<b>SUBTOTAL =</b>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 60%;">\$</td> <td></td> </tr> <tr> <td>\$ 2090.00**</td> <td></td> </tr> </table>	\$		\$ 2090.00**																
\$																				
\$ 2090.00**																				
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 60%;">\$</td> <td></td> </tr> <tr> <td>\$ -0-</td> <td></td> </tr> </table>	\$		\$ -0-																
\$																				
\$ -0-																				
<b>TOTAL NATIONAL FEE =</b>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 60%;">\$</td> <td></td> </tr> <tr> <td>\$ 2090.00**</td> <td></td> </tr> </table>	\$		\$ 2090.00**																
\$																				
\$ 2090.00**																				
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property +	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 60%;">\$</td> <td></td> </tr> <tr> <td>\$ 40.00</td> <td></td> </tr> </table>	\$		\$ 40.00																
\$																				
\$ 40.00																				
<b>TOTAL FEES ENCLOSED =</b>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 60%;">\$</td> <td></td> </tr> <tr> <td>\$ 2130.00**</td> <td></td> </tr> </table>	\$		\$ 2130.00**																
\$																				
\$ 2130.00**																				
<b>**Filing Fees calculated after entry of the Preliminary Amendment (A) filed concurrently          herewith.</b>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 60%;">Amount to be refunded:</td> <td>\$</td> </tr> <tr> <td>charged:</td> <td>\$</td> </tr> </table>	Amount to be refunded:	\$	charged:	\$															
Amount to be refunded:	\$																			
charged:	\$																			
a. <input checked="" type="checkbox"/> A check in the amount of \$ <u>2,130.00</u> to cover the above fees is enclosed. b. <input type="checkbox"/> Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees. A duplicate copy of this sheet is enclosed. c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. <u>50-1281</u> . A duplicate copy of this sheet is enclosed. d. <input type="checkbox"/> Fees are to be charged to a credit card. <b>WARNING:</b> Information on this form may become public. <b>Credit card          information should not be included on this form.</b> Provide credit card information and authorization on PTO-2038.																				
<b>NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR          1.137 (a) or (b)) must be filed and granted to restore the application to pending status.</b>																				
SEND ALL CORRESPONDENCE TO: GRIFFIN & SZIPL, P.C. Suite PH-1 2300 Ninth Street, South Arlington, VA 22204-2320 Telephone: (703) 979-5700 Facsimile: (703) 979-7429 Customer No.: 24203	SIGNATURE <u>SZIPL, Joerg-Uwe</u> NAME 31,799 REGISTRATION NUMBER Date: 20 December 2001																			

10/018690

531 Rec'd PCT. . . 20 DEC 2001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: )  
CHIBA, Tatsuo, et al. ) Atty. Docket No.: TSUK 0005  
Serial No. \_\_\_\_\_ (corresponding to )  
PCT/JP00/04028 filed 21 June 2000) )  
Filed: Herewith )  
For: PHOTSENSITIVE ELEMENT, )  
PHOTSENSITIVE ELEMENT ROLL, )  
PROCESS FOR THE PREPARATION )  
OF RESIST PATTERN USING THE )  
SAME, RESIST PATTERN, RESIST )  
PATTERN LAMINATED )  
SUBSTRATE, PROCESS FOR THE )  
PREPARATION OF WIRING ) Date: 20 December 2001  
PATTERN AND WIRING PATTERN )

**PRELIMINARY AMENDMENT (A)**

**BOX: PCT (DO/EO/US)**  
Assistant Commissioner for Patents  
Washington, D. C. 20231

Sir:

Prior to calculating the filing fee, kindly amend the above-captioned application as follows:

**IN THE CLAIMS:**

Kindly amend claims 20, 22, 29-31 and 40 and replace them with the following:

20. (Amended) A photosensitive element roll according to Claim 1, wherein the above photosensitive element is wound up or rolled around a core.

22. (Amended) A process for preparing a resist pattern which comprises laminating the photosensitive element according to Claim 1 to a substrate for forming a circuit so that the photosensitive resin composition layer is closely contacted to the substrate, irradiating imagewise active light to photocure the exposed portion, and removing an unexposed

portion by development.

29. (Amended) The resist pattern according to Claim 24, wherein a width of the resist pattern is 1  $\mu\text{m}$  or more.

30. (Amended) The resist pattern according to Claim 24, wherein a height of the resist pattern is 1 to 150  $\mu\text{m}$ .

31. (Amended) The resist pattern laminated substrate which comprises the resist pattern according to Claim 24, wherein it is formed on a substrate for preparing a circuit.

40. (Amended) The wiring pattern according to Claim 34, wherein a height of the wiring pattern is 0.01 to 200  $\mu\text{m}$ .

With the above amendments, claims 20, 22, 29-31 and 40 have been amended to delete the multiple dependencies and make those claims singly dependent. A marked-up version showing the changes made to those claims is attached for the convenience of the Examiner.

In view of the above, it is believed that the application is in good condition for examination, and the Examiner's early and favorable consideration is respectfully requested. Questions are welcomed by the below-signed attorney for applicants.

Respectfully submitted,

GRIFFIN & SZIPL, P.C.

SZIPL, Joerg-Uwe  
Reg. No. 31,799

GRIFFIN & SZIPL, PC  
 Suite PH-1  
 2300 Ninth Street, South  
 Arlington, VA 22204

Telephone: (703) 979-5700  
Facsimile: (703) 979-7429  
Customer No.: 24203

**VERSION WITH MARKINGS TO SHOW CLAIM CHANGES MADE**

20. (Amended) A photosensitive element roll according to ~~any one of Claims 1 to 19~~Claim 1, wherein the above photosensitive element is wound up or rolled around a core.

22. (Amended) A process for preparing a resist pattern which comprises laminating the photosensitive element according to ~~any one of Claims 1 to 20~~Claim 1 to a substrate for forming a circuit so that the photosensitive resin composition layer is closely contacted to the substrate, irradiating imagewise active light to photocure the exposed portion, and removing an unexposed portion by development.

29. (Amended) The resist pattern according to ~~any one of Claims 24 to 28~~Claim 24, wherein a width of the resist pattern is 1  $\mu\text{m}$  or more.

30. (Amended) The resist pattern according to ~~any one of Claims 24 to 28~~Claim 24, wherein a height of the resist pattern is 1 to 150  $\mu\text{m}$ .

31. (Amended) The resist pattern laminated substrate which comprises the resist pattern according to ~~any one of Claims 24 to 28~~Claim 24, wherein it is formed on a substrate for preparing a circuit.

40. (Amended) The wiring pattern according to ~~any one of Claims 34 to 38~~Claim 34, wherein a height of the wiring pattern is 0.01 to 200  $\mu\text{m}$ .

10/018690  
531 Rec'd PCT/FP 20 DEC 2001

3/1/01

1018690-122001

Attached is a second copy of English translation of International Application No.  
PCT/JP00/04028 filed on 21 June 2000 in compliance with the requirements of 35  
U.S.C. § 154(d)(4).

## SPECIFICATION

PHOTOSENSITIVE ELEMENT, PHOTOSENSITIVE ELEMENT ROLL, PROCESS  
5 FOR THE PREPARATION OF RESIST PATTERN USING THE SAME, RESIST  
PATTERN, RESIST PATTERN LAMINATED SUBSTRATE, PROCESS FOR THE  
PREPARATION OF WIRING PATTERN AND WIRING PATTERN

Technical field

10           This invention relates to a photosensitive element, a photosensitive element roll, a process for the preparation of a resist pattern using the same, the resist pattern, a resist pattern laminated substrate, a process for the preparation of a wiring pattern and the wiring pattern.

Prior art

In the field of a preparation of a printed wiring board, precision processing of a metal, etc., a photosensitive resin composition and a photosensitive element have been widely used as a resist material to be used for etching, plating, etc.

A photosensitive element generally comprises three layers of a light-transmissive support film, a photosensitive resin composition layer and a protective film. As a method of using the same, there may be mentioned a method in which a protective film is firstly peeled off, the element is bonded by pressure (laminated) so as to directly contact with a photosensitive resin layer, a negative film which has been subjected to patterning is adhered onto a light-transmissive film, active light (ultraviolet rays are frequently used) is irradiated (exposed), and then, unnecessary portions are removed by spraying an organic solvent or an aqueous alkaline solution to form (develop) a resist pattern. A method which employs an aqueous alkaline solution as a developing solution has been highly demanded in view of an environmental problem.

35 In recent years, electronic equipment has been promoted to be small sized and light weighted. A printed wiring board



has been also required to make the circuit fine, a resist pattern is made finer line and high resolution of a photosensitive element has been required. However, such demands cannot be satisfied by the conventional photosensitive element

5 comprising the three-layer structure. That is, it is exposed through a light-transmissive support film so that a thickness of the film is required to be thin as much as possible to obtain high resolution. On the other hand, the support is required to have a self-retaining property with a certain extent to  
10 accomplish a role as a support for a photosensitive resin composition to be coated. It is generally required to have a thickness of 15 to 25  $\mu\text{m}$ . Thus, it is the present status that the demand of high resolution cannot be accomplished when a light-transmissive support film with the conventional grade is  
15 used.

To these demands, various attempts have been made to accomplish high resolution. For example, there is a method in which a support film is peeled off before exposure and a negative film is directly adhered onto a photosensitive resin  
20 composition layer. In general, the photosensitive resin composition layer has an adhesive property with a certain extent so as to adhere to a substrate material. Thus, when the method is directly applied to, the negative film and the photosensitive resin composition layer are adhered whereby the problems arise  
25 that the negative film is difficultly peeled off so that operatability is lowered, the negative film is stained by the photosensitive resin or sensitivity is lowered due to inhibition by oxygen in air.

Thus, as an attempt to improve the above method, there  
30 has been proposed a method in which a photosensitive resin composition layer is provided with two or more layers and a layer directly contacting with the negative film is made non-adhesive layer (see Japanese Provisional Patent Publications (Kokai) No. Sho. 61-31855 (1986), No. Hei. 1-221735 (1989), No. Hei. 2-  
35 230149 (1990), etc.). However, this method requires troublesome operation to make a multi-layered photosensitive

resin composition layers and has no effect on sensitivity.

Also, as the other method, an attempt of providing an intermediate layer on the photosensitive resin composition layer to solve these problems has been described in, for example,  
5 Japanese Patent Publications (Kokoku) No. Sho. 54-12215 (1979) and Sho. 56-40824 (1981), Japanese Provisional Patent Publications No. Sho. 55-501072 (1980), No. Sho. 47-469 (1972), No. Sho. 59-97138 (1984), No. Sho. 59-216141 (1984) and No. Sho. 63-197942 (1988), etc. However, in either of these methods,  
10 an intermediate layer must be provided between a support film and a photosensitive resin composition layer so that coating must be carried out twice, and handling of a thin intermediate layer is difficult.

An object of the present invention is to provide a  
15 photosensitive element excellent in side wall flatness of a resist pattern, flatness at an upper surface of the same, resolution, adhesiveness, alkaline developability, productivity and operatability, and having less number of mouse bites.

20 An object of the present invention is to provide a photosensitive element excellent in side wall flatness of a resist pattern in addition to the above effects.

25 An object of the present invention is to provide a photosensitive element excellent in resolution in addition to the above effects.

Another object of the present invention is to provide a photosensitive element excellent in dimensional stability at the time of lamination in addition to the above effects.

30 Further object of the present invention is to provide a photosensitive element excellent in film strength after hardening the resist in addition to the above effects.

Still further object of the present invention is to provide a photosensitive element excellent in peeling property in addition to the above effects.

35 Still further object of the present invention is to provide a photosensitive element excellent in plating

resistance in addition to the above effects.

Still further object of the present invention is to provide a photosensitive element excellent in adhesiveness in addition to the above effects.

- 5 Still further object of the present invention is to provide a photosensitive element excellent in cold flow property at storage in addition to the above effects.

- Another object of the present invention is to provide a photosensitive element roll excellent in side wall flatness of  
10 a resist pattern, flatness at an upper surface of the same, resolution, adhesiveness, winding deviation during shipping, productivity and operatability, and having less number of mouse bites.

- A further object of the present invention is to provide  
15 a process for preparing a resist pattern excellent in side wall flatness of a resist pattern, flatness at an upper surface of the same, resolution, adhesiveness, productivity and operatability, and having less number of mouse bites.

- A further object of the present invention is to provide  
20 a resist pattern excellent in side wall flatness of a resist pattern, flatness at an upper surface of the same, resolution, adhesiveness, productivity and operatability, and having less number of mouse bites.

- A further object of the present invention is to provide  
25 a resist pattern laminated substrate excellent in side wall flatness of a resist pattern, flatness at an upper surface of the same, resolution, adhesiveness, winding deviation at transfer, productivity and operatability, and less number of mouse bites.

- A further object of the present invention is to provide  
30 a process for preparing a wiring pattern excellent in side wall flatness of a resist pattern, electric resistance and appearance of lines.

- A further object of the present invention is to provide  
35 a wiring pattern excellent in side wall flatness of a resist pattern, electric resistance and appearance of lines.

Disclosure of the invention

The present invention relates to a photosensitive element comprising a support film which comprises a biaxially oriented polyester film and a photosensitive resin composition layer  
5 formed on one surface of the polyester film, wherein a resin layer containing fine particles is formed on the opposite surface of the support film to which the photosensitive resin composition layer is formed, and said photosensitive resin composition comprises

- 10 (A) a binder polymer having a carboxyl group,  
(B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and  
(C) a photopolymerization initiator.

15 Also, the present invention relates to a photosensitive element having a layer of a photosensitive resin composition on a support film, which comprises having a heat shrinkage ratio to the lateral direction of the support film at 200°C for 30 minutes being 0.00 to 4.00% and said photosensitive resin  
20 composition comprises

- (A) a binder polymer having a carboxyl group,  
(B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and  
25 (C) a photopolymerization initiator.

The present invention also relates to the above photosensitive element in which the heat shrinkage ratio to the lateral direction of the support film at 150°C for 30 minutes is 0.00 to 0.20%.

30 The present invention also relates to the above photosensitive element in which the heat shrinkage ratio to the lateral direction of the support film at 105°C for 30 minutes is 0.00 to 0.20%.

35 Also, the present invention relates to a photosensitive element having a layer of a photosensitive resin composition on a support film, which comprises having a heat shrinkage ratio

to the lateral direction of the support film at 150°C for 30 minutes being 0.00 to 0.20% and said photosensitive resin composition comprises

- (A) a binder polymer having a carboxyl group,
- 5 (B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and
- (C) a photopolymerization initiator.

The present invention also relates to the above  
10 photosensitive element in which the heat shrinkage ratio to the lateral direction of the support film at 105°C for 30 minutes is 0.00 to 0.20%.

Moreover, the present invention relates to a photo-sensitive element having a layer of a photosensitive resin  
15 composition on a support film, which comprises having a contact angle (°) of the support film by water satisfying the following numerical formula (1):

$$\frac{(\text{Contact angle at X surface})}{(\text{Contact angle at Y surface})} > 1.1 \quad (1)$$

20 X surface: a surface of the support film to which the photosensitive resin composition is coated and dried,  
Y surface: a surface of the support film opposite to the surface to which the photosensitive resin composition is coated,

- 25 and said photosensitive resin composition comprises
- (A) a binder polymer having a carboxyl group,
  - (B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and
  - 30 (C) a photopolymerization initiator.

Furthermore, the present invention relates to the above photosensitive element in which the support film is a support film comprising a resin layer containing fine particles being  
laminated on one surface of a biaxially oriented polyester film,  
35 and the photosensitive resin composition layer is provided at the opposite surface of the support film to which the resin layer

is formed.

The present invention also relates to the above photosensitive element in which an average particle size of the fine particles is 0.01 to 5.0  $\mu\text{m}$ .

5 The present invention also relates to the above photosensitive element in which a thickness of the resin layer containing fine particles is 0.05 to 5.0  $\mu\text{m}$ .

The present invention also relates to the above photosensitive element in which a haze of the support film is  
10 0.01 to 5.0%.

The present invention also relates to the above photosensitive element in which a heat shrinkage ratio in the longitudinal direction of the support film at 105°C for 30 minutes is 0.30 to 0.60%.

15 The present invention also relates to the above photosensitive element in which a heat shrinkage ratio in the longitudinal direction of the support film at 150°C for 30 minutes is 1.00 to 1.90%.

The present invention also relates to the above  
20 photosensitive element in which a heat shrinkage ratio in the longitudinal direction of the support film at 200°C for 30 minutes is 3.00 to 6.50%.

The present invention also relates to the above photosensitive element in which a weight average molecular  
25 weight of (A) the binder polymer having a carboxyl group is 20,000 to 300,000.

The present invention also relates to the above photosensitive element in which an acid value of (A) the binder polymer having a carboxyl group is 50 to 300 mg KOH/g.

30 The present invention also relates to the above photosensitive element in which (B) the photopolymerizable compound is a bisphenol A type (meth)acrylate compound.

The present invention also relates to the above photosensitive element in which (C) the photopolymerization  
35 initiator is 2,4,5-triaryl imidazole dimer.

The present invention also relates to the above

photosensitive element in which formulation amounts of Components (A), (B) and (C) are 40 to 80 parts by weight of Component (A) based on 100 parts by weight of Component (A) and Component (B) in total, 5 20 to 60 parts by weight of Component (B) based on 100 parts by weight of Component (A) and Component (B) in total, and 0.01 to 20 parts by weight of Component (C) based on 100 parts by weight of Component (A) and Component (B) in total.

Moreover, the present invention relates to a photo-  
10 sensitive element roll in which the above photosensitive element is wound up or rolled around a core.

The present invention also relates to a photosensitive element roll in which the photosensitive element is wound up around a core, wherein a total height of winding deviation at  
15 the edge surface of the photosensitive element roll after naturally dropping the photosensitive element roll five times from the height of 10 cm to the collision surface so that the axis direction of the core becomes perpendicular to the collision surface is 1 mm or less.

20 The present invention also relates to a process for preparing a resist pattern which comprises laminating the above photosensitive element to a substrate for forming a circuit so that the photosensitive resin composition layer is closely contacted to the substrate, irradiating imagewisely active  
25 light to photocure the exposed portion, and removing an unexposed portion by development.

The present invention also relates to a resist pattern prepared by the above preparation process.

The present invention also relates to the above resist  
30 pattern in which unevenness on the side surface of the resist pattern is 0 to 3.0  $\mu\text{m}$ .

The present invention also relates to the above resist pattern in which a number of unevenness larger than 3.0  $\mu\text{m}$  on the center line of the side surface of the resist pattern is  
35 0 to 5/4 mm.

The present invention also relates to the above resist

pattern in which a mathematical average roughness ( $R_a$ ) on the side surface of the resist pattern is 0 to 2.0  $\mu\text{m}$ .

The present invention also relates to the above resist pattern in which a maximum height ( $R_y$ ) on the side surface of  
5 the resist pattern is 0 to 3.0  $\mu\text{m}$ .

The present invention also relates to a resist pattern comprising a maximum height ( $R_y$ ) on the side surface of the resist pattern of 0 to 3.0  $\mu\text{m}$ .

The present invention also relates to the above resist  
10 pattern in which a width of the resist pattern is 1  $\mu\text{m}$  or more.

The present invention also relates to the above resist pattern in which a height of the resist pattern is 1 to 150  $\mu\text{m}$ .

The present invention also relates to a resist pattern laminated substrate which comprises the above resist pattern  
15 being formed on a substrate for preparing a circuit.

The present invention also relates to a process for preparing a wiring pattern which comprises subjecting the above resist pattern laminated substrate to etching or plating.

The present invention also relates to a wiring pattern  
20 prepared by the above process for preparing the wiring pattern.

The present invention also relates to the above wiring pattern in which unevenness on the side surface of the wiring pattern is 0 to 3.0  $\mu\text{m}$ .

The present invention also relates to the above wiring  
25 pattern in which a number of unevenness larger than 3.0  $\mu\text{m}$  on the center line of the side surface of the wiring pattern is 0 to 5/4 mm.

The present invention also relates to the above wiring pattern in which a mathematical average roughness ( $R_a$ ) on the  
30 side surface of the wiring pattern is 0 to 2.0  $\mu\text{m}$ .

The present invention also relates to the above wiring pattern in which a maximum height ( $R_y$ ) on the side surface of the wiring pattern is 0 to 3.0  $\mu\text{m}$ .

The present invention also relates to a wiring pattern  
35 comprising a maximum height ( $R_y$ ) on the side surface of the wiring pattern of 0 to 3.0  $\mu\text{m}$ .



The present invention also relates to the above wiring pattern in which a width of the wiring pattern is  $1\text{ }\mu\text{m}$  or more.

The present invention also relates to the above wiring pattern in which a height of the wiring pattern is 0.01 to 200  $\mu\text{m}$ .

#### Brief description of the drawings

Fig. 1 is a schematic drawing showing a test method of winding deviation of a photosensitive element roll.

Fig. 2A and 2B are schematic drawings showing a method for measuring a height of winding deviation of a photosensitive element roll.

Fig. 3 is a schematic drawing showing an L-square.

Fig. 4A is a schematic drawing showing winding deviation-occurred portion of a photosensitive element roll and Fig. 4B is an enlarged partial view thereof.

Fig. 5 is a schematic drawing showing a resist pattern.

Fig. 6 is a schematic drawing showing a measurement method of a concavo-convex portion on the side surface of a resist pattern.

Fig. 7 is a sectional view of a resist pattern.

Fig. 8 is a sectional view of concave-convex portion on the side surface of a resist pattern.

#### Best mode for carrying out the invention

In the following, the present invention is explained in detail. Incidentally, a (meth)acrylic acid in the present specification means acrylic acid and methacrylic acid corresponding to the same, a (meth)acrylate means an acrylate and a methacrylate corresponding to the same, and a (meth)-acryloyl group means an acryloyl group and a methacryloyl group corresponding to the same.

The photosensitive element of the present invention has four aspects.

The first aspect of the photosensitive element of the present invention resides in a photosensitive element com-

prising a support film which comprises a biaxially oriented polyester film and a resin layer containing fine particles on one surface of the film, and a layer of a photosensitive resin composition formed on the opposite surface of the support film to which the resin layer is formed, and said photosensitive resin composition comprises (A) a binder polymer having a carboxyl group, (B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and (C) a photopolymerization initiator.

The second aspect of the photosensitive element of the present invention resides in a photosensitive element having a layer of a photosensitive resin composition on a support film, which comprises having a heat shrinkage ratio in the lateral direction of the support film at 200°C for 30 minutes being 0.00 to 4.00% and said photosensitive resin composition comprises (A) a binder polymer having a carboxyl group, (B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and (C) a photopolymerization initiator.

The third aspect of the photosensitive element of the present invention resides in a photosensitive element having a layer of a photosensitive resin composition on a support film, which comprises having a heat shrinkage ratio in the lateral direction of the support film at 150°C for 30 minutes being 0.00 to 0.20% and said photosensitive resin composition comprises (A) a binder polymer having a carboxyl group, (B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and (C) a photopolymerization initiator.

The fourth aspect of the photosensitive element of the present invention resides in a photosensitive element having a layer of a photosensitive resin composition on a support film, which comprises having a contact angle (°) of the support film with water satisfying the above numerical formula (2), and said photosensitive resin composition comprises (A) a binder polymer having a carboxyl group, (B) a photopolymerizable compound

having at least one polymerizable ethylenically unsaturated group in the molecule, and (C) a photopolymerization initiator.

The support film in the first aspect of the photosensitive element of the present invention comprises a resin layer  
5 containing fine particles laminated on one surface of a biaxially oriented polyester film. It is preferred that the second photosensitive element, third photosensitive element and fourth photosensitive element use the support film having the above-mentioned structure.

10 An average particle size of the above fine particles is preferably 0.01 to 5.0  $\mu\text{m}$ , more preferably 0.02 to 4.0  $\mu\text{m}$ , and particularly preferably 0.03 to 3.0  $\mu\text{m}$ . If the average particle size is less than 0.01  $\mu\text{m}$ , workability tends to be lowered, while if it exceeds 5.0  $\mu\text{m}$ , resolution and sensitivity tend to be  
15 lowered.

A formulating amount of the above fine particles may vary depending on, for example, a kind of a base resin constituting the resin layer, a kind and an average particle size of the fine particles, physical properties of the support film to be  
20 obtained, etc.

As the above fine particles, there may be mentioned inorganic particles such as silica, kaolin, talc, alumina, calcium phosphate, titanium dioxide, calcium carbonate, barium sulfate, calcium fluoride, lithium fluoride, zeolite,  
25 molybdenum sulfide, etc.; organic particles such as cross-linked polymer particles, calcium oxalate, etc. In view of transparency, particles of silica are preferred. These fine particles may be used singly or in combination of two or more.

As the base resin to constitute the resin layer containing  
30 the above-mentioned fine particles, there may be mentioned, for example, a polyester type resin, a polyurethane type resin, an acrylic type resin, a mixture thereof, a copolymer thereof, etc.

A thickness of the resin layer is preferably 0.01 to 5.0  $\mu\text{m}$ , more preferably 0.05 to 3.0  $\mu\text{m}$ , particularly preferably 0.1  
35 to 2.0  $\mu\text{m}$ , extremely preferably 0.1 to 1.0  $\mu\text{m}$ . If the thickness is less than 0.01  $\mu\text{m}$ , the effects of the present invention cannot

likely be obtained, while if it exceeds 5.0  $\mu\text{m}$ , transparency of the polyester film is poor, and sensitivity and resolution tend to be lowered.

5 The method of laminating the above resin layer on one surface of the above biaxially oriented polyester film is not particularly limited, and may be mentioned, for example, a coating method, etc.

10 The polyester type resin constituting the above biaxially oriented polyester film may include, for example, aromatic linear polyester comprising an aromatic dicarboxylic acid and a diol as constitutional components, such as polyethylene terephthalate, polybutylene terephthalate, polyethylene naphthalate, etc.; aliphatic linear polyester comprising an aliphatic dicarboxylic acid and a diol as constitutional  
15 components; a polyester type resin mainly comprising polyester such as a copolymer of the above materials; etc. These resins may be used singly or in combination of two or more.

20 Fine particles may be added to the biaxially oriented polyester film to which the above resin layer is laminated. As the fine particles, there may be mentioned, for example, the same fine particles to be contained in the above resin layer. A content thereof is preferably 0 to 80 ppm, more preferably 0 to 60 ppm, particularly preferably 0 to 40 ppm. If the content thereof exceeds 80 ppm, transparency of the polyester film is  
25 lowered as a whole, and resolution and sensitivity tend to be lowered.

A method for preparing the above biaxially oriented polyester film is not particularly limited, and there may be used, for example, a biaxially stretching method, etc. Also,  
30 after forming the above resin layer on one surface of an unstretched film or a mono-axially stretched film, and the film is further stretched to make a support film.

A thickness of the above biaxially stretched polyester film is preferably 1 to 100  $\mu\text{m}$ , more preferably 1 to 50  $\mu\text{m}$ ,  
35 particularly preferably 1 to 30  $\mu\text{m}$ , and extremely preferably 10 to 30  $\mu\text{m}$ . If the thickness is less than 1  $\mu\text{m}$ , preparation

of the film is not easy and the film cannot easily be commercially available, while if it exceeds 100  $\mu$ m, cheapness tends to be lowered.

The support film in the second aspect of the photo-sensitive element of the present invention has a heat shrinkage ratio in the lateral direction of the support film at 200°C for 30 minutes of 0.00 to 4.00%. It is preferred that the first photosensitive element, the third photosensitive element and the fourth photosensitive element use the support film having the heat shrinkage ratio within the above range.

The heat shrinkage ratio in the lateral direction of the above support film at 200°C for 30 minutes is required to be 0.00 to 4.00%, preferably 0.00 to 3.00%, more preferably 0.00 to 2.00%, particularly preferably 0.00 to 1.50%, extremely preferably 0.00 to 1.30%, most extremely preferably 0.00 to 1.00%. If the heat shrinkage ratio exceeds 4.00%, dimensional precision tends to be lowered.

The support film in the third aspect of the photosensitive element of the present invention has a heat shrinkage ratio in the lateral direction of the support film at 150°C for 30 minutes of 0.00 to 0.20%. It is preferred that the first photosensitive element, the second photosensitive element and the fourth photosensitive element use the support film having the heat shrinkage ratio within the above range.

The heat shrinkage ratio in the lateral direction of the above support film at 150°C for 30 minutes is required to be 0.00 to 0.20%, preferably 0.00 to 0.15%, more preferably 0.00 to 0.10 %, particularly preferably 0.00 to 0.05%, extremely preferably 0.00 to 0.04%, most extremely preferably 0.00 to 0.03%. If the heat shrinkage ratio exceeds 0.20%, dimensional precision tends to be lowered.

A haze of the above support film is preferably 0.01 to 5.0%, more preferably 0.01 to 3.0%, particularly preferably 0.01 to 2.0%, extremely preferably 0.01 to 1.0%. If the haze is less than 0.01%, preparation of the film is not easy, while if it exceeds 5.0%, sensitivity and resolution tend to be

lowered. Incidentally, the haze in the present invention is measured according to JIS K 7105 and, for example, measurement can be carried out by using a commercially available turbidimeter such as NDH-1001DP (available from Nippon Denshoku Kogyo K.K., Japan, trade name), etc.

The heat shrinkage ratio in the lateral direction of the above support film at 105°C for 30 minutes is 0.00 to 0.20%, more preferably 0.00 to 0.15%, particularly preferably 0.00 to 0.10%, extremely preferably 0.00 to 0.05%. If the heat shrinkage ratio exceeds 0.20%, dimensional precision tends to be lowered.

The support film in the fourth aspect of the photosensitive element of the present invention is preferably a support film satisfying the relationship between the contact angle of X surface (the surface of the support film to which the photosensitive resin composition is coated and dried) of the support film and the contact angle of Y surface (the surface of the support film opposite to the surface to which the photosensitive resin composition is coated and dried), of  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface}) > 1.1$ . It is preferred that the first photosensitive element, the second photosensitive element and the third photosensitive element use the support film satisfying the above relationship of contact angles.

The relationship of the contact angles of the above support film is required to be  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface}) > 1.1$ , preferably  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface}) > 1.15$ , more preferably  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface}) > 1.2$ , particularly preferably  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface}) > 1.25$ , most preferably  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface}) > 1.3$ , extremely preferably  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface}) > 1.35$ , most extremely preferably  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface}) > 1.4$ . Also, as the upper limit of  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface})$ , it is preferably 5.0, more preferably 4.0,

particularly preferably 3.0, extremely preferably 2.0. If the relationship of the contact angles is less than 1.1, dimensional precision tends to be lowered. Incidentally, the contact angles in the present specification can be measured according to JIS R 3257 and measured by a static dropping method.

The heat shrinkage ratio in the longitudinal direction of the above support film at 105°C for 30 minutes is preferably 0.30 to 0.60%, more preferably 0.35 to 0.55%, particularly preferably 0.40 to 0.50 %. If the heat shrinkage ratio is less than 0.30%, the polyester film tends to be brittle, while if it exceeds 0.60%, dimensional change of the photosensitive element tends to be occurred at the time of lamination.

The heat shrinkage ratio in the longitudinal direction of the above support film at 150°C for 30 minutes is preferably 1.00 to 1.90%, more preferably 1.10 to 1.70%, particularly preferably 1.20 to 1.60 %. If the heat shrinkage ratio is less than 1.00%, the polyester film tends to be brittle, while if it exceeds 1.90%, dimensional change of the photosensitive element tends to be occurred at the time of lamination.

The heat shrinkage ratio to the longitudinal direction of the above support film at 200°C for 30 minutes is preferably 3.00 to 6.50%, more preferably 3.30 to 5.00%, particularly preferably 3.60 to 4.70 %. If the heat shrinkage ratio is less than 3.00%, the polyester film tends to be brittle, while if it exceeds 6.50%, dimensional change of the photosensitive element tends to be occurred at the time of lamination.

The heat shrinkage ratio of the present invention can be measured as mentioned below. Test pieces each having a width of 20 mm and a length of 150 mm were cut out along with the longitudinal direction and the lateral direction of the film, 5 pieces per each, and gage points are marked at the center portion of the respective test pieces with a distance of about 100 mm. The test pieces are vertically hanged in a thermostat with internal air circulation maintained at the above temperature  $\pm 3^{\circ}\text{C}$  for 30 minutes, taken out and allowed to stand at room temperature for 30 minutes, and the distance between

the gage points is measured. The heat shrinkage ratio is calculated according to following scheme (2) and an average thereof is obtained whereby the value can be obtained.

Incidentally, other regulations are according to JIS C2318-5 1997 (5.3.4 Dimensional change).

$$\Delta L(\%) = (L_0 - L) / L_0 \times 100 \quad (2)$$

$\Delta L$ : a heat shrinkage ratio (%),

$L_0$ : a distance (mm) between gage points before heating,

$L$ : a distance (mm) between gage points after heating.

10 As a commercially available support film, there may be mentioned, for example, A2100-16, A4100-25 (both trade names) available from Toyo Boseki K.K., Japan, etc.

A thickness of the above support film is preferably 1 to 100  $\mu\text{m}$ , more preferably 1 to 50  $\mu\text{m}$ , particularly preferably 1 to 30  $\mu\text{m}$ , extremely preferably 10 to 30  $\mu\text{m}$ . If the thickness 15 is less than 1  $\mu\text{m}$ , mechanical strength tends to be lowered and a polymer film tends to be torn at the time of coating, while if it exceeds 100  $\mu\text{m}$ , resolution tends to be lowered and a cost tends to be expensive.

20 The photosensitive element of the first aspect of the present invention can be obtained by using a support film comprising a polyester film in which a resin layer containing fine particles is laminated on one surface of a biaxially oriented polyester film, coating a photosensitive resin 25 composition on the other surface of the support opposed to the surface to which the above resin layer is formed, and drying the same. The above coating can be carried out by the conventionally known method by using a roll coater, a comma coater, a gravure coater, an air knife coater, a die coater, 30 a bar coater, etc. Drying can be carried out at 80 to 150°C for about 5 to 30 minutes.

Also, the photosensitive element of the second aspect and the photosensitive element of the third aspect of the present invention can be obtained, for example, when a resin layer 35 containing fine particles is present on one surface of the above support film depending on necessity, a layer of the photo-



sensitive resin composition is provided by coating on the surface opposite to the surface to which the above resin layer is provided, and drying. The above coating and drying may be mentioned the same ones as those mentioned in the photosensitive element of the first aspect.

(A) The binder polymer having a carboxyl group of the present invention can be produced, for example, by subjecting a polymerizable monomer having a carboxyl group and other polymerizable monomer to radical polymerization.

The polymerizable monomer having a carboxyl group may include, for example, (meth)acrylic acid,  $\alpha$ -bromo(meth)acrylic acid,  $\alpha$ -chloro(meth)acrylic acid,  $\beta$ -furyl(meth)acrylic acid,  $\beta$ -styryl(meth)acrylic acid, maleic acid, maleic anhydride, maleic acid monoester such as monomethyl maleate, monoethyl maleate, monoisopropyl maleate, etc., fumaric acid, cinnamic acid,  $\alpha$ -cyanocinnamic acid, itaconic acid, crotonic acid, propiolic acid, etc.

The other polymerizable monomer is not specifically limited, and may include, for example, styrene, a styrene derivative in which  $\alpha$ -position or aromatic ring is substituted by a substituent(s) such as vinyl toluene,  $\alpha$ -methylstyrene, etc., acrylamide such as diacetoneacrylamide, etc., acrylonitrile, an ester of vinyl alcohol such as vinyl-n-butyl ether, etc., alkyl (meth)acrylate, tetrahydrofurfuryl (meth)acrylate, dimethylaminoethyl (meth)acrylate, diethylaminoethyl (meth)acrylate, glycidyl (meth)acrylate, 2,2,2-trifluoroethyl (meth)acrylate, 2,2,3,3-tetrafluoropropyl (meth)acrylate, etc.

As the above alkyl (meth)acrylate, there may be mentioned, for example, a compound represented by the following formula (I):



wherein  $\text{R}^1$  represents a hydrogen atom or a methyl group; and  $\text{R}^2$  represents an alkyl group having 1 to 12 carbon

atoms,

a compound in which a hydroxyl group, an epoxy group, a halogen group, etc. is substituted at the alkyl group of the above-mentioned compound, or the like.

As the alkyl group having 1 to 12 carbon atoms of  $R^2$  in the above formula (I), there may be mentioned, for example, a methyl group, an ethyl group, a propyl group, a butyl group, a pentyl group, a hexyl group, a heptyl group, an octyl group, a nonyl group, a decyl group, an undecyl group, a dodecyl group and a structural isomer of these groups.

As a monomer represented by the above formula (I), there may be mentioned, for example, methyl (meth)acrylate, ethyl (meth)acrylate, propyl (meth)acrylate, butyl (meth)acrylate, pentyl (meth)acrylate, hexyl (meth)acrylate, heptyl (meth)acrylate, octyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, nonyl (meth)acrylate, decyl (meth)acrylate, undecyl (meth)acrylate, dodecyl (meth)acrylate, etc. These monomers may be used singly or in combination of two or more.

Also, in the binder polymer which is Component (A) of the present invention, styrene or styrene derivative may be preferably contained as a polymerizable monomer in view of flexibility of the resulting material.

The styrene or styrene derivative is preferably contained in an amount of 0.1 to 30% by weight as a copolymerizable component to make adhesive property and peeling property good, more preferably 1 to 28% by weight, particularly preferably 1.5 to 27% by weight. If the amount is less than 0.1% by weight, adhesive property tends to be lowered, while if it exceeds 30% by weight, a size of peeled pieces becomes large and a peeling time tends to be long.

These binder polymers may be used singly or in combination of two or more. When the binder polymer is used in combination of two or more, there may be mentioned, for example, two or more binder polymers comprising different copolymer components, two or more binder polymers having different weight average molecular weights, two or more binder polymers having different

dispersibilities, etc.

(A) The binder polymer having a carboxyl group according to the present invention preferably has a weight average molecular weight of 20,000 to 300,000 in view of film-forming property and resolution, more preferably 25,000 to 200,000, particularly preferably 30,000 to 150,000. If the weight average molecular weight is less than 20,000, developing solution resistance tends to be lowered, while if it exceeds 300,000, a developing time tends to be long. Incidentally, in the present specification, the weight average molecular weight is measured by using gel permeation chromatography and calculated by using a calibration curve of standard polystyrenes.

An acid value of (A) the binder polymer having a carboxyl group according to the present invention is preferably 50 to 300 mg KOH/g, more preferably 60 to 250 mg KOH/g, particularly preferably 70 to 200 mg KOH/g. If the acid value is less than 50 mg KOH/g, a developing time tends to be long, while if it exceeds 300 mg KOH/g, developing solution resistance of the photocured resist tends to be lowered.

(B) The photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule according to the present invention may include, for example, a compound obtained by reacting a polyvalent alcohol with an  $\alpha,\beta$ -unsaturated carboxylic acid; a bisphenol A type (meth)acrylate compound such as 2,2-bis(4-((meth)acryloxypolyethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxypolypropoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxypolyethoxypolypropoxy)phenyl)propane, etc.; a compound obtained by reacting a glycidyl group-containing compound with an  $\alpha,\beta$ -unsaturated carboxylic acid; a urethane monomer such as a (meth)acrylate compound having a urethane bond, etc.; nonylphenyldioxyethylene (meth)acrylate,  $\gamma$ -chloro- $\beta$ -hydroxypropyl- $\beta'$ -(meth)acryloyloxyethyl-o-phthalate,  $\beta$ -hydroxyethyl- $\beta'$ -(meth)acryloyloxyethyl-o-phthalate,  $\beta$ -hydroxypropyl- $\beta'$ -(meth)acryloyloxyethyl-o-phthalate, alkyl



ethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxytetradecaethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxy-pentadecaethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxyhexadecaethoxy)phenyl)propane, etc. Of these, 2,2-bis(4-((meth)acryloxy-pentaethoxy)phenyl)propane is commercially available as BPE-500 (trade name, available from Shin-Nakamura Kagaku Kogyo K.K., Japan), and 2,2-bis(4-((meth)acryloxy-pentadecaethoxy)phenyl)propane is commercially available as BPE-1300 (trade name, available from Shin-Nakamura Kagaku Kogyo K.K., Japan). These compounds may be used singly or in combination of two or more.

As the above 2,2-bis(4-((meth)acryloxy-polyethoxy-polypropoxy)phenyl)propane, there may be mentioned, for example, 2,2-bis(4-((meth)acryloxydiethoxyoctapropoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxytetraethoxytetrapropoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxyhexaethoxyhexapropoxy)phenyl)propane, etc. These compounds may be used singly or in combination of two or more.

As the above glycidyl group-containing compound, there may be mentioned, for example, trimethylolpropanetri-glycidyl ether tri(meth)acrylate, 2,2-bis(4-((meth)acryloxy-2-hydroxy-propyloxy)phenyl, etc.

As the above urethane monomer, there may be mentioned, for example, an addition reaction product of a (meth)acryl monomer having a OH group at the  $\beta$ -position and a diisocyanate compound such as isophorone diisocyanate, 2,6-tolylene diisocyanate, 2,4-tolylene diisocyanate, 1,6-hexamethylene diisocyanate, etc.; tris((meth)acryloxytetraethylene glycol isocyanate)hexamethylene isocyanurate, EO-modified urethane di(meth)acrylate, EO and PO-modified urethane di(meth)acrylate, etc. Incidentally, EO represents ethylene oxide and the EO-modified compound has a block structure of an ethylene oxide group. Also, PO represents propylene oxide and the PO-modified compound has a block structure of a propylene oxide group.

As the EO-modified urethane di(meth)acrylate, there may

be mentioned, for example, UA-11 (trade name, available from Shin-Nakamura Kagaku Kogyo K.K., Japan), etc. Also, the EO and PO-modified urethane di(meth)acrylate, there may be mentioned, for example, UA-13 (trade name, available from Shin-Nakamura Kagaku Kogyo K.K., Japan), etc.

As the above alkyl (meth)acrylate, there may be mentioned, for example, methyl (meth)acrylate, ethyl (meth)acrylate, butyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, etc.

These compounds may be used singly or in combination of two or more.

(C) The photopolymerization initiator in the present invention may include, for example, aromatic ketones such as benzophenone, N,N'-tetramethyl-4,4'-diaminobenzophenone (Michler's ketone), N,N'-tetraethyl-4,4'-diaminobenzophenone, 4-methoxy-4'-dimethylaminobenzophenone, 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)-butanone-1,2-methyl-1-[4-(methylthio)phenyl]-2-morpholino-propanone-1, etc.; quinones such as 2-ethylanthraquinone, phenanthrenequinone, 2-tert-butylanthraquinone, octamethylanthraquinone, 1,2-benzanthraquinone, 2,3-benzanthraquinone, 2-phenylanthraquinone, 2,3-diphenylanthraquinone, 1-chloroanthraquinone, 2-methylanthraquinone, 1,4-naphthoquinone, 9,10-phenanthraquinone, 2-methyl-1,4-naphthoquinone, 2,3-dimethylanthraquinone, etc.; benzoin ether compounds such as benzoin, methylbenzoin, ethylbenzoin, etc.; benzil derivatives such as benzil dimethyl ketal, etc.; 2,4,5-triarylimidazole dimers such as 2-(o-chlorophenyl)-4,5-diphenylimidazole dimer, 2-(o-chlorophenyl)-4,5-di(methoxyphenyl)imidazole dimer, 2-(o-fluorophenyl)-4,5-diphenylimidazole dimer, 2-(p-methoxyphenyl)-4,5-diphenylimidazole dimer, etc.; acridine derivatives such as 9-phenylacridine, 1,7-bis(9,9'-acridinyl)heptane, etc.; N-phenylglycine, N-phenylglycine derivative, coumarin type compound, etc.

Substituents of the two aryl groups possessed by 2,4,5-triarylimidazole may be the same to provide a symmetric

compound or different from each other to provide an asymmetric compound.

Also, a thioxanthone type compound and a tertiary amine compound may be used in combination as in the combination of  
5 diethylthioxanthone and dimethylaminobenzoic acid.

Also, 2,4,5-triarylimidazole dimer is more preferably used in view of adhesiveness and sensitivity. These compounds may be used singly or in combination of two or more.

An amount of Component (A) to be formulated in the present  
10 invention is preferably 50 to 70 parts by weight, more preferably 55 to 65 parts by weight based on the total 100 parts by weight of Component (A) and Component (B). If the amount is less than 40 parts by weight, film-forming property tends to be lowered when it is used as a photosensitive element, while  
15 if it exceeds 80 parts by weight, photocuring tends to be insufficient.

An amount of Component (B) to be formulated in the present invention is preferably 30 to 50 parts by weight, more preferably 35 to 45 parts by weight based on the total 100 parts  
20 by weight of Component (A) and Component (B). If the amount is less than 20 parts by weight, photocuring tends to be insufficient, while if it exceeds 60 parts by weight, film-forming property tends to be lowered.

An amount of Component (C) to be formulated in the present  
25 invention is preferably 0.01 to 20 parts by weight, more preferably 0.05 to 10 parts by weight, particularly preferably 0.1 to 5 parts by weight based on the total 100 parts by weight of Component (A) and Component (B). If the amount is less than 0.01 part by weight, sensitivity tends to be insufficient, while  
30 if it exceeds 20 parts by weight, resolution tends to be worsened.

To the photosensitive resin composition of the present invention may be added, depending on necessity, a dye such as Malachite Green, etc.; a light coloring agent such as leuco  
35 Crystal Violet, etc.; a thermal coloration preventive agent; a plasticizer such as p-toluenesulfonic acid amide, etc., a

pigment, a filler, a defoaming agent, a flame retardant, a stabilizer, an adhesiveness-imparting agent, a leveling agent, a peeling promoting agent, an antioxidant, a perfume, an imaging agent, a heat cross-linking agent, etc., each in an amount of 0.01 to 20 parts by weight based on the total 100 parts by weight of Component (A) and Component (B). These compounds may be used singly or in combination of two or more.

The photosensitive resin composition of the present invention may be coated as a solution with a solid content of about 30 to 60% by weight by dissolving it in a solvent such as methyl alcohol, ethyl alcohol, acetone, methyl ethyl ketone, ethylene glycol monomethyl ether, ethylene glycol monoethyl ether, toluene, N-dimethylformamide, etc., or a mixed solvent of the above solvents, if necessary.

Also, a thickness of the photosensitive resin composition layer may vary depending on the use, and preferably 1 to 200  $\mu\text{m}$ , more preferably 1 to 100  $\mu\text{m}$ , particularly preferably 1 to 30  $\mu\text{m}$  with a thickness after drying. If the thickness is less than 1  $\mu\text{m}$ , formation of a film tends to be industrially difficult, while if it exceeds 200  $\mu\text{m}$ , photocuring property at the bottom portion of a resist tends to be worsened.

The photosensitive element of the present invention comprising two layers of the thus obtained photosensitive resin composition layer and a support film is stored by, for example, winding it around a core as such or further laminating a protective film on the other surface (the surface opposed to the surface existing the support film) of the photosensitive resin composition layer. Incidentally, at this time, it is preferred to wind the photosensitive element so that the support film is the outermost layer. A winding rate and a winding tension at the time of winding can be optionally determined. As the above protective film, there may be mentioned, for example, an inert polyolefin film such as polyethylene, polypropylene, etc., and the polyethylene film is preferred in view of peeling property from the photosensitive resin composition layer. Also, it is preferred to use a protective



film with a low fish eye to avoid occurrence of air voids. An edge surface separator is preferably provided at the edge surface of the above roll-shaped photosensitive element roll to protect the edge surface, and a moistureproof edge surface separator is preferably provided to prevent edge fusion. The photosensitive element roll is preferably packed by wrapping with a black sheet having a low permeability. In the present specification, the term "edge fusion" means a phenomenon in which the photosensitive resin composition layer is oozed out from the edge surface of the photosensitive element roll.

As the above core, a cylindrical shape core is preferred and the core may comprise, for example, plastics such as polyethylene resin, polypropylene resin, polystyrene resin, polyvinyl chloride resin, ABS resin (acrylonitrile-butadiene-styrene copolymer), etc., paper, and the like.

The photosensitive element roll of the present invention is a material, as shown in Fig. 1, in which a photosensitive element 2 is winding around a core 1. When the photosensitive element roll 3 is naturally dropped five times from the height of 10 cm to a collision surface 4 so that the axis direction of the core 1 becomes perpendicular to the collision surface 4, a total height of winding deviation at the edge surface of the photosensitive element roll 3 after the above operation is 1 mm or less.

The above dropping is preferably carried out continuously five times, more preferably continuously carried out five times in 1 minute. Also, the above dropping test is preferably carried out after storing the above photosensitive element roll in an insulating container at about 0 to 10°C for 8 to 12 hours.

A size of the above core may be mentioned, for example, a diameter of 5 to 10 cm and a length to the axis direction of 10 to 80 cm, and the like.

A width of the photosensitive element roll when the photosensitive element roll is winding around the core is not specifically limited, and preferably narrower than the length of the axis direction of the core, more preferably about 1 to

10 cm shorter than that of the core. A length of the photosensitive element roll to be wound around the core is not particularly limited, and preferably about 10 to 550 m.

5 The above collision surface 4 is preferably a material which is not broken even when the photosensitive element roll is dropped thereon, and may comprise, for example, a concrete surface, a metal surface, etc.

10 The total height of winding deviation at the edge surface of the photosensitive element roll after it was naturally dropped five times can be measured as mentioned below. First, as shown in Fig. 2, Fig. 3 and Fig. 4, an L-square 5 is put at the edge portion of the photosensitive element roll 3 so that an X piece of the L-square 5 becomes parallel to the plane passing through the axis direction of the core 1 and a Y piece of the  
15 same becomes perpendicular to the plane passing through the axis direction of the core 1. Next, a distance (a height d of winding deviation) of the winding deviation 6 occurred from the edge portion of the photosensitive element roll 3 to the top point is measured. In the present specification, as the height of  
20 the winding deviation, the maximum value of the winding deviation is employed and the value is made as a height of the winding deviation of the photosensitive element roll. Also, in the present specification, winding deviation means a difference of deviation at the edge surface of the photo-  
25 sensitive element roll before dropping and after dropping.

When a resist pattern is prepared by using the above photosensitive element, if a protective film is present, it can be prepared, for example, by removing the protective film, and bringing the photosensitive resin composition layer into  
30 contact with a substrate for forming a circuit by pressure under heating whereby the layer is laminated to the substrate. The lamination is preferably carried out under reduced pressure to obtain good adhesion and conformity. The surface to be laminated is generally a metal surface, but it is not  
35 particularly limited to these materials. A temperature of the photosensitive resin composition layer to be heated is

preferably 70 to 130°C, and a contact-bonding pressure is preferably 0.1 to 1 MPa (1 to 10 kgf/cm<sup>2</sup>), but it is not particularly limited to these ranges. Also, when the photosensitive resin composition layer is heated at 70 to 130°C, it is not necessary to pre-heat the substrate for forming a circuit. Moreover, in order to further improve lamination characteristics, a pre-heating treatment of the substrate for forming a circuit may be carried out.

Then, the photosensitive resin composition layer which has been thus laminated is imagewise irradiated by an active light through a negative or positive mask pattern which is so-called art work. At this time, when a polymer film existing on the photosensitive resin composition layer is transparent, active light may be irradiated as such, and when the polymer film is opaque, it is necessary to remove the film as a matter of course.

As a light source of the active light, there may be used a conventionally known light source which effectively irradiates ultraviolet rays such as carbon arc lamp, mercury vapor arc lamp, ultra-high pressure mercury lamp, high pressure mercury lamp, xenon lamp, etc. Also, a light source which irradiates visible rays, such as a photoflood lamp for photography, a sunlight lamp, etc. may be used.

Next, after exposure, when a support is present on the photosensitive resin composition layer, the support is removed, unexposed portion is removed and developed by wet development, dry development, etc., to prepare a resist pattern.

In the case of the wet development, development is carried out by the conventionally known method such as spray, dipping by rocking, brushing, scraping, etc. by using a developing solution corresponding to a photosensitive resin composition such as an aqueous alkaline solution, an aqueous developing solution, an organic solvent and the like.

As the developing solution, those which are safe, stable and easily operable such as an aqueous alkaline solution may be used.

As a base of the above aqueous alkaline solution, there may be used an alkali hydroxide such as a hydroxide of lithium, sodium or potassium, etc.; an alkali carbonate such as a carbonate or a bicarbonate of lithium, sodium, potassium or ammonium, etc.; an alkali metal phosphate such as potassium phosphate, sodium phosphate, etc.; and an alkali metal pyrophosphate such as sodium pyrophosphate, potassium pyrophosphate, etc.

As the aqueous alkaline solution to be used for development, preferred are a 0.1 to 5% by weight diluted sodium carbonate solution, a 0.1 to 5% by weight diluted potassium carbonate solution, a 0.1 to 5% by weight diluted sodium hydroxide solution, a 0.1 to 5% by weight diluted sodium tetraborate solution, and the like.

A pH of the aqueous alkaline solution to be used for development is preferably within the range of 9 to 11, and a temperature thereof can be controlled depending on the developability of the photosensitive resin composition layer.

To the aqueous alkaline solution may be added a surfactant, a defoaming agent, a small amount of an organic solvent to accelerate the development, etc.

The above aqueous developing solution comprises water or an aqueous alkaline solution, and at least one of an organic solvent. Here, as the alkali substance, in addition to the above substances, there may be mentioned, for example, borax, sodium metasilicate, tetramethylammonium hydroxide, ethanolamine, ethylenediamine, diethylenetriamine, 2-amino-2-hydroxymethyl-1,3-propanediol, 1,3-diaminopropanol-2, morpholine, etc.

A pH of the developing solution is preferably as low as possible within the range during which development of the resist can be sufficiently carried out, it is preferably a pH of 8 to 12, more preferably a pH of 9 to 10.

As the above organic solvent, there may be mentioned, for example, triacetonealcohol, acetone, ethyl acetate, alkoxy-ethanol having an alkoxy group with 1 to 4 carbon atoms, ethyl

alcohol, isopropyl alcohol, butyl alcohol, diethylene glycol monomethyl ether, diethylene glycol monoethyl ether, diethylene glycol monobutyl ether, etc. These solvents may be used singly or in combination of two or more.

- 5 A concentration of the organic solvent is generally preferably 2 to 90% by weight and a temperature thereof may be adjusted depending on the developability.

To the aqueous developing solution may be added a small amount of a surfactant, a defoaming agent, etc.

- 10 As an organic solvent type developing agent which can be used singly, there may be mentioned, for example, 1,1,1-trichloroethane, N-methylpyrrolidone, N,N-dimethylformamide, cyclohexanone, methyl isobutyl ketone,  $\gamma$ -butyrolactone, etc. Water is preferably added to the organic solvent in the range of 1 to 20% by weight to prevent inflammation. Also, if  
15 necessary, two or more developing systems may be used in combination.

- In the developing system, there are a dipping system, a bottle system, a spray system, brushing, scraping, etc., and  
20 a high pressure spray system is most suitable for improving resolution.

As a post-developing treatment, the resist pattern may be further cured by heating at about 60 to 250°C or subjecting to exposure with 0.2 to 10 mJ/cm<sup>2</sup>, if necessary, and used.

- 25 The resist pattern of the present invention has further four characteristic features.

The first characteristic feature of the resist pattern according to the present invention resides in that unevenness on the side surface of the resist pattern is 0 to 3.0  $\mu$ m.

- 30 The second characteristic feature of the resist pattern according to the present invention resides in that a number of unevenness larger than 3.0  $\mu$ m on the center line of the side surface of the resist pattern is 0 to 5/4 mm.

- The third characteristic feature of the resist pattern  
35 according to the present invention resides in that a mathematical average roughness ( $R_a$ ) on the side surface of the resist

pattern is 0 to 2.0  $\mu\text{m}$ .

The fourth characteristic feature of the resist pattern according to the present invention resides in that a maximum height ( $R_y$ ) on the side surface of the resist pattern is 0 to 3.0  $\mu\text{m}$ .

Here, the side surface of the resist pattern according to the present invention means, as shown in Fig. 5, a surface of a resist pattern in the direction perpendicular to the substrate 15 (a thickness direction of a photosensitive resin composition layer in a photosensitive element) in the resist pattern 7 obtained by imagewise exposing a layer of the photosensitive resin composition layer laminated on the substrate from upper portion of the substrate to active light and then subjecting to development.

Also, unevenness on the side surface of the resist pattern according to the present invention means, as shown in Fig. 5, linear grooves 9 existing on the side surface 8 of the resist pattern perpendicular to the substrate 15 (a thickness direction of a photosensitive resin composition layer in a photosensitive element).

The unevenness on the side surface of the resist pattern in the first characteristic feature of the resist pattern according to the present invention is required to be 0 to 3.0  $\mu\text{m}$ , preferably 0 to 2.8  $\mu\text{m}$ , more preferably 0 to 2.5  $\mu\text{m}$ , further preferably 0 to 2.3  $\mu\text{m}$ , particularly preferably 0 to 2.0  $\mu\text{m}$ , extremely preferably 0 to 1.8  $\mu\text{m}$ , and most extremely preferably 0 to 1.5  $\mu\text{m}$ . If the value exceeds 3.0  $\mu\text{m}$ , side wall flatness, electric resistance and line appearance of the resulting wiring pattern tend to be poor.

The number of unevenness larger than 3.0  $\mu\text{m}$  on the center line of the side surface of the resist pattern in the second characteristic feature of the resist pattern according to the present invention is required to be 0 to 5/4 mm, preferably 0 to 4/4 mm, more preferably 0 to 3/4 mm, further preferably 0 to 2/4 mm, particularly preferably 0 to 1/4 mm, and extremely preferably 0/4 mm. If the value exceeds 5/4 mm, side wall

flatness, electric resistance and line appearance of the resulting wiring pattern tend to be poor.

The mathematical average roughness ( $R_a$ ) on the side surface of the resist pattern in the third characteristic feature of the resist pattern according to the present invention is required to be 0 to 2.0  $\mu\text{m}$ , preferably 0 to 1.8  $\mu\text{m}$ , more preferably 0 to 1.5  $\mu\text{m}$ , further preferably 0 to 1.3  $\mu\text{m}$ , particularly preferably 0 to 1.0  $\mu\text{m}$ , extremely preferably 0 to 0.8  $\mu\text{m}$ , and most extremely preferably 0 to 0.5  $\mu\text{m}$ . If the value exceeds 2.0  $\mu\text{m}$ , side wall flatness, electric resistance and line appearance of the resulting wiring pattern tend to be poor.

The maximum height ( $R_y$ ) on the side surface of the resist pattern in the fourth characteristic feature of the resist pattern according to the present invention is required to be 0 to 3.0  $\mu\text{m}$ , preferably 0 to 2.8  $\mu\text{m}$ , more preferably 0 to 2.5  $\mu\text{m}$ , further preferably 0 to 2.3  $\mu\text{m}$ , particularly preferably 0 to 2.0  $\mu\text{m}$ , extremely preferably 0 to 1.8  $\mu\text{m}$ , and most extremely preferably 0 to 1.5  $\mu\text{m}$ . If the value exceeds 3.0  $\mu\text{m}$ , side wall flatness, electric resistance and line appearance of the resulting wiring pattern tend to be poor.

The width of the resist pattern according to the present invention is not specifically limited, and preferably 1  $\mu\text{m}$  or more, more preferably 3  $\mu\text{m}$  or more, further preferably 5  $\mu\text{m}$  or more, particularly preferably 5 to 1000  $\mu\text{m}$ , more preferably 6 to 1000  $\mu\text{m}$ , extremely preferably 7 to 1000  $\mu\text{m}$ , more extremely preferably 8 to 1000  $\mu\text{m}$ , further extremely preferably 9 to 900  $\mu\text{m}$ , and most extremely preferably 10 to 800  $\mu\text{m}$ .

The height of the resist pattern according to the present invention is not specifically limited, and preferably 1 to 150  $\mu\text{m}$ , more preferably 1 to 110  $\mu\text{m}$ , further preferably 2 to 100  $\mu\text{m}$ , particularly preferably 3 to 90  $\mu\text{m}$ , extremely preferably 4 to 80  $\mu\text{m}$ , and most extremely preferably 5 to 75  $\mu\text{m}$ .

The unevenness on the side surface of the resist pattern according to the present invention can be measured, for example, as mentioned below. First, a photosensitive resin composition layer is laminated on a substrate, and then, the material is

exposed (30 to 200 mJ/cm<sup>2</sup> or so: it is optionally selected so that a rectangular-shaped resist pattern can be obtained) and developed (0.1 to 5% by weight dilute sodium carbonate solution, etc., 20 to 40°C or so: it is optionally selected so that a rectangular-shaped resist pattern can be obtained) by using a linear negative pattern (having windows through which active light with the size of 100 μm x 1 cm is passed) to form a linear and rectangular-shaped resist pattern (width: 100 μm, length: 1 cm, height: a thickness of the photosensitive resin composition layer).

Here, as shown in Fig. 6, a surface of the resist pattern perpendicular to the substrate and parallel to the lengthwise direction of the resist pattern 7 is made a side surface 8 of the resist pattern, and a lateral width of the side surface 8 of the resist pattern is made a height of the resist pattern. Also, the lateral width of the surface of the resist pattern parallel to the substrate and perpendicular to the side surface of the resist pattern is made a width of the resist pattern. Then, on the side surface 8 of the resist pattern, two lines perpendicular to the substrate are optionally drawn and their respective center points are each called as a center point S 10 and a center point T 11. These center points S 10 and T 11 are linked with a line and the line is called to as a center line 12 (the center points S 10 and T 11 are placed so that the length of the center line 12 becomes 4 mm) of the side surface 8 of the resist pattern. Here, unevenness on the side surface of the resist pattern is measured within the range of the center line 12 (length: 4 mm) of the side surface 8 of the resist pattern.

The above-mentioned unevenness on the center line of the side surface of the resist pattern means, as shown in Figs. 7 and 8, a line perpendicular to a tangent line of the two convex portions adjacent to each other and parallel to the substrate, and shows a distance between a deepest point 13 of the concave portion located between the two convex portions adjacent to each other and a point of intersection 14 which is a point of



intersection of a line passing through the deepest point 13 of the concave portions located between the two convex portions adjacent to each other and the above tangent line. Incidentally, Fig. 7 is a sectional view in which it is cut with a surface passing through the center line on the side surface of the resist pattern and parallel to the substrate, and Fig. 8 is an enlarged sectional view of the uneven portion of Fig. 7.

The unevenness on the center line on the side surface of the above-mentioned resist pattern can be measured by, for example, an optical microscope, a scanning type electron microscope (SEM), a contact type surface roughness measurement apparatus, a non-contact type three dimensional surface roughness measurement apparatus, a Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan, etc.), a Color Lazer 3D Profile Microscope (VK-8500, trade name, manufactured by Keyence, Japan, etc.) and the like.

The unevenness on the side surface of the resist pattern can be easily measured from the perpendicular direction by using an apparatus capable of measuring the unevenness to the depth direction without contacting the material to be measured such as the above-mentioned Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan, etc.), the Color Lazer 3D Profile Microscope (VK-8500, trade name, manufactured by Keyence, Japan, etc.) and the like.

When the unevenness on the side surface of the resist pattern is measured by using the above-mentioned optical microscope, the scanning type electron microscope (SEM), etc., the unevenness can be easily measured by observing, from the upper side of the substrate, the sectional surface of the resist pattern along with the center line obtained by cutting the side surface 8 of the resist pattern in a direction passing through the center line 12 which is parallel to the substrate and perpendicular to the side surface of the resist pattern. Also, the unevenness can be observed from diagonally upper the resist pattern without cutting the same.

The mathematical average roughness ( $R_a$ ) and the maximum

height ( $R_y$ ) on the side surface of the resist pattern according to the present invention can be also measured, for example, by the same manner as that of the method for measuring the unevenness on the side surface of the resist pattern as mentioned above. Incidentally, the mathematical average roughness ( $R_a$ ) and the maximum height ( $R_y$ ) in the present invention are measured according to JIS B 0601 and values at which a cut-off value  $\lambda_c=0.8$  mm and an evaluation length  $l_n=4$  mm.

10 The mathematical average roughness ( $R_a$ ) and the maximum height ( $R_y$ ) of the side surface of the resist pattern as mentioned above can be measured, for example, by a contact type surface roughness measuring apparatus, a Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan, etc.), a Color Laser 3D Profile Microscope (VK-8500, trade name, manufactured by Keyence, Japan, etc.) and the like. It is preferred to use a Profile Measurement Microscope, a Color Laser 3D Profile Microscope, etc., which are capable of effecting non-contact measurement.

20 For effecting etching of a metal surface to be carried out after development, there may be used a cupric chloride solution, a ferric chloride solution, an alkali etching solution, a hydrogen peroxide type etching solution, etc. It is desired to use a ferric chloride solution in the point of having a good etch factor.

When a printed wiring board is to be produced by using the photosensitive element according to the present invention, the surface of a substrate for forming a circuit is treated by the conventionally known method such as etching, plating, etc., by using the developed resist pattern as a mask.

As the above plating method, there may be mentioned, for example, copper plating such as copper sulfate plating, copper pyrophosphate plating, etc.; solder plating such as high slow solder plating, etc.; nickel plating such as Watt bath (nickel sulfate-nickel chloride) plating, nickel sulfamate plating, etc.; gold plating such as hard gold plating, soft gold plating,

etc.

As mentioned above, a wiring pattern can be obtained by subjecting the substrate for forming a circuit on which a resist pattern has been formed to etching or plating.

5 On the other hand, the wiring pattern of the present invention has further four characteristics as mentioned below.

The first characteristic feature of the wiring pattern according to the present invention resides in that unevenness on the side surface of the resist pattern is 0 to 3.0  $\mu\text{m}$ .

10 The second characteristic feature of the wiring pattern according to the present invention resides in that a number of unevenness larger than 3.0  $\mu\text{m}$  on the center line of the side surface of the resist pattern is 0 to 5/4 mm.

15 The third characteristic feature of the wiring pattern according to the present invention resides in that a mathematical average roughness ( $R_a$ ) on the side surface of the resist pattern is 0 to 2.0  $\mu\text{m}$ .

20 The fourth characteristic feature of the wiring pattern according to the present invention resides in that a maximum height ( $R_y$ ) on the side surface of the resist pattern is 0 to 3.0  $\mu\text{m}$ .

The wiring pattern of the present invention tends to be etched or plated along with the unevenness on the side surface of the resist pattern so that it is preferred that the unevenness on the side surface of the wiring pattern is small in view of line appearance and electric resistance.

The unevenness on the side surface of the wiring pattern in the first characteristic feature of the wiring pattern according to the present invention is required to be 0 to 3.0  $\mu\text{m}$ , preferably 0 to 2.8  $\mu\text{m}$ , more preferably 0 to 2.5  $\mu\text{m}$ , further preferably 0 to 2.3  $\mu\text{m}$ , particularly preferably 0 to 2.0  $\mu\text{m}$ , extremely preferably 0 to 1.8  $\mu\text{m}$ , and most extremely preferably 0 to 1.5  $\mu\text{m}$ . If the value exceeds 3.0  $\mu\text{m}$ , side wall flatness, electric resistance and line appearance of the resulting wiring pattern tend to be poor.

The number of unevenness larger than 3.0  $\mu\text{m}$  on the center

line of the side surface of the wiring pattern in the second characteristic feature of the wiring pattern according to the present invention is required to be 0 to  $5/4$  mm, preferably 0 to  $4/4$  mm, more preferably 0 to  $3/4$  mm, further preferably 0 to  $2/4$  mm, particularly preferably 0 to  $1/4$  mm, and extremely preferably  $0/4$  mm. If the value exceeds  $5/4$  mm, side wall flatness, electric resistance and line appearance of the resulting wiring pattern tend to be poor.

The mathematical average roughness ( $R_a$ ) on the side surface of the wiring pattern in the third characteristic feature of the wiring pattern according to the present invention is required to be 0 to  $2.0\text{ }\mu\text{m}$ , preferably 0 to  $1.8\text{ }\mu\text{m}$ , more preferably 0 to  $1.5\text{ }\mu\text{m}$ , further preferably 0 to  $1.3\text{ }\mu\text{m}$ , particularly preferably 0 to  $1.0\text{ }\mu\text{m}$ , extremely preferably 0 to  $0.8\text{ }\mu\text{m}$ , and most extremely preferably 0 to  $0.5\text{ }\mu\text{m}$ . If the value exceeds  $2.0\text{ }\mu\text{m}$ , side wall flatness, electric resistance and line appearance of the resulting wiring pattern tend to be poor.

The maximum height ( $R_y$ ) on the side surface of the wiring pattern in the fourth characteristic feature of the wiring pattern according to the present invention is required to be 0 to  $3.0\text{ }\mu\text{m}$ , preferably 0 to  $2.8\text{ }\mu\text{m}$ , more preferably 0 to  $2.5\text{ }\mu\text{m}$ , further preferably 0 to  $2.3\text{ }\mu\text{m}$ , particularly preferably 0 to  $2.0\text{ }\mu\text{m}$ , extremely preferably 0 to  $1.8\text{ }\mu\text{m}$ , and most extremely preferably 0 to  $1.5\text{ }\mu\text{m}$ . If the value exceeds  $3.0\text{ }\mu\text{m}$ , side wall flatness, electric resistance and line appearance of the resulting wiring pattern tend to be poor.

The width of the wiring pattern according to the present invention is not specifically limited, and preferably  $1\text{ }\mu\text{m}$  or more, more preferably  $3\text{ }\mu\text{m}$  or more, further preferably  $5\text{ }\mu\text{m}$  or more, particularly preferably  $5$  to  $1000\text{ }\mu\text{m}$ , more particularly preferably  $6$  to  $1000\text{ }\mu\text{m}$ , extremely preferably  $7$  to  $1000\text{ }\mu\text{m}$ , more extremely preferably  $8$  to  $1000\text{ }\mu\text{m}$ , further extremely preferably  $9$  to  $900\text{ }\mu\text{m}$ , and most extremely preferably  $10$  to  $800\text{ }\mu\text{m}$ .

The height of the wiring pattern according to the present invention is not specifically limited, and preferably  $0.01$  to  $200\text{ }\mu\text{m}$ , more preferably  $0.02$  to  $190\text{ }\mu\text{m}$ , further preferably  $0.03$

to 180  $\mu\text{m}$ , particularly preferably 0.05 to 150  $\mu\text{m}$ , further particularly preferably 0.08 to 130  $\mu\text{m}$ , extremely preferably 0.10 to 100  $\mu\text{m}$ , further extremely preferably 1.00 to 100  $\mu\text{m}$ , and most extremely preferably 5.00 to 50  $\mu\text{m}$ .

5       The unevenness on the side surface of the wiring pattern according to the present invention can be measured, for example, as mentioned below. First, a resist pattern is formed on a substrate for forming a circuit, and then, the resulting material is subjected to etching (an aqueous ferric chloride  
10 solution, an aqueous cupric chloride solution, etc., 40 to 60°C or so) to prepare a linear wiring pattern (width: 100  $\mu\text{m}$ , length: 1 cm, height: a thickness of the metal layer of the substrate for forming a circuit). Here, in the same manner as in the side surface of the resist pattern, a surface of the wiring pattern  
15 perpendicular to the substrate and parallel to the lengthwise direction of the wiring pattern is made a side surface of the wiring pattern, and a lateral width of the side surface of the wiring pattern is made a height of the wiring pattern. Also, the lateral width of the surface of the wiring pattern parallel  
20 to the substrate and perpendicular to the side surface of the wiring pattern is made a width of the wiring pattern. Then, on the side surface of the wiring pattern, two lines perpendicular to the substrate are optionally drawn and their respective center points are each called as a center point M  
25 and a center point N. These center points M and N are linked with a line and the line is called to as a center line (the center points M and N are placed so that the length of the center line becomes 4 mm) of the side surface of the wiring pattern. Here, unevenness on the side surface of the wiring pattern is measured  
30 within the range of the center line (length: 4 mm) of the side surface of the wiring pattern.

The above-mentioned unevenness on the center line on the side surface of the wiring pattern means a line perpendicular to a tangent line of the two convex portions adjacent to each  
35 other and parallel to the substrate as in the unevenness on the center line on the side surface of the resist pattern, and shows

a distance between a deepest point of the concave portion located between the two convex portions adjacent to each other and a point of intersection which is a point of intersection of a line passing through the deepest point of the concave portions located between the two convex portions adjacent to each other and the above tangent line.

The unevenness on the center line on the side surface of the above-mentioned wiring pattern can be measured by, for example, an optical microscope, a scanning type electron microscope (SEM), a contact type surface roughness measurement apparatus, a non-contact type three dimensional surface roughness measurement apparatus, a Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan, etc.), a Color Lazer 3D Profile Microscope (VK-8500, trade name, manufactured by Keyence, Japan, etc.) and the like.

The unevenness on the side surface of the wiring pattern can be easily measured from the perpendicular direction by using an apparatus capable of measuring the unevenness to the depth direction without contacting the material to be measured such as the above-mentioned Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan, etc.), the Color Lazer 3D Profile Microscope (VK-8500, trade name, manufactured by Keyence, Japan, etc.) and the like.

When the unevenness on the side surface of the wiring pattern is measured by using the above-mentioned optical microscope, the scanning type electron microscope (SEM), etc., the unevenness can be easily measured by observing, from the upper side of the substrate, the sectional surface of the wiring pattern along with the center line obtained by cutting the side surface of the wiring pattern in a direction passing through the center line which is parallel to the substrate and perpendicular to the side surface of the wiring pattern. Also, the unevenness can be observed from diagonally upper the wiring pattern without cutting the same.

The mathematical average roughness ( $R_a$ ) and the maximum height ( $R_y$ ) on the side surface of the wiring pattern according

to the present invention can be also measured, for example, by the same manner as that of the method for measuring the unevenness on the side surface of the wiring pattern as mentioned above. Incidentally, the mathematical average roughness ( $R_a$ ) and the maximum height ( $R_y$ ) in the present invention are measured according to JIS B 0601 and values at which a cut-off value  $\lambda_c=0.8$  mm and an evaluation length  $l_n=4$  mm.

The mathematical average roughness ( $R_a$ ) and the maximum height ( $R_y$ ) of the side surface of the wiring pattern as mentioned above can be measured, for example, by a contact type surface roughness measuring apparatus, a Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan, etc.), a Color Laser 3D Profile Microscope (VK-8500, trade name, manufactured by Keyence, Japan, etc.) and the like. It is preferred to use a Profile Measurement Microscope, a Color Laser 3D Profile Microscope, etc., which are capable of effecting non-contact measurement.

Then, the resist pattern can be peeled off, for example, by an aqueous alkali solution stronger than the aqueous alkali solution used in the development.

As such an aqueous strong alkali solution, there may be used an aqueous 1 to 10% by weight sodium hydroxide solution, an aqueous 1 to 10% by weight potassium hydroxide solution and the like.

As the peeling method, there may be mentioned, for example, a dipping system, a spraying system, etc., and the dipping system and the spraying system may be used singly or in combination. Also, the printed wiring board to which a resist pattern has been formed may be a multi-layer printed wiring board.

#### Examples

Next, the present invention will be explained in more detail by referring to Examples.

Examples 1 and 2, and Comparative examples 1 to 3

Component (A) was synthesized by using the components shown in Table 1 to prepare a solution, and Component (B), Component (C), other components and solvents were mixed with the solution to prepare a solution of a photosensitive resin composition.

Table 1

	Material	Formulation amount
Component (A)	40% by weight solution of methacrylic acid/methyl methacrylate/styrene copolymer (weight ratio: 25/50/25, weight average molecular weight: 70,000, acid value: 163 mg KOH/g) in toluene/methyl cellosolve (weight ratio: 4/6)	150 g (solid component: 60 g)
Component (B)	2,2-Bis(4-(methacryloxy-pentaethoxy)phenyl)propane	30.0 g
	$\gamma$ -Chloro- $\beta$ -hydroxypropyl- $\beta'$ -methacryloxyethyl-o-phthalate	10.0 g
Component (C)	2-(o-Chlorophenyl)-4,5-diphenylimidazole dimer	3.0 g
	N,N'-Tetraethyl-4,4'-diaminobenzophenone	0.15 g
Other Components	Leuco Crystal Violet	0.5 g
	Marachite Green	0.05 g
	p-Toluenesulfonic amide	4.0 g
Solvents	Acetone	10.0 g
	Toluene	10.0 g
	Methanol	3.0 g
	N,N-Dimethylformamide	3.0 g

The resulting solution of the photosensitive resin composition was uniformly coated on a support film (A2100-16 and A4100-25 (biaxially oriented polyethylene terephthalate each having a resin layer containing fine particles on one surface thereof), available from Toyo Boseki K.K., Japan; G2-16, G2-19 and V-20 (polyethylene terephthalate each having no resin layer containing fine particles), available from Teijin Limited,



Japan) shown in Table 2 and dried in an oven with internal air circulation at 100°C for 10 minutes to obtain respective photosensitive elements. Each film thickness of the photosensitive resin composition layer after drying was 20  $\mu\text{m}$ .

5 Hazes of the support films shown in Table 2 were measured according to JIS K 7105 by using a haze meter (TC-H3DP, trade name, manufactured by Tokyo Denshoku K.K., Japan).

Also, 5 sheets of test pieces with a width of 20 mm and a length of 150 mm were cut out along with the longitudinal  
10 direction and the lateral direction, respectively, and then, gage points were marked at the center portion of the respective test pieces with a distance of 100 mm. The test pieces were vertically hanged in a thermostat with internal air circulation maintained at  $105 \pm 3^\circ\text{C}$ ,  $150 \pm 3^\circ\text{C}$  and  $200 \pm 3^\circ\text{C}$  for 30 minutes,  
15 taken out and allowed to stand at room temperature for 30 minutes, and the distance between the gage points was measured. The heat shrinkage ratio was calculated from the above-mentioned scheme (2) and an average of the respective samples was calculated.

Next, a copper surface of a copper-clad laminated board  
20 (MCL-E-61, trade name, available from Hitachi Chemical Co., Ltd., Japan) which comprises a glass-epoxy material on which copper foils (each a thickness of 35  $\mu\text{m}$ ) had been laminated on the both surfaces thereof was polished by using a polishing machine (manufactured by Sankei K.K., Japan) having a brush  
25 corresponding to #600, washed with water and dried with air stream. The resulting copper-clad laminated board was heated to 80°C, and the above-mentioned photosensitive resin composition layer was laminated on the copper surface at 120°C and 0.4 MPa (4 kgf/cm<sup>2</sup>).

30 Thereafter, exposure was carried out by using an exposure machine (model: HMW-201B, trade name, manufactured by Orc Seisakusho Co., Japan) having a 3KW ultra high pressure mercury lamp in such an energy dose that the number of remaining step grades after development became 8.0, using a photo tool having  
35 a Stofer 21 grade step tablet as a negative mask and a photo tool having a wiring pattern with a line/space of 30/400 to

250/400 (resolution, unit:  $\mu\text{m}$ ) as a negative mask for evaluating adhesive property. Then, the support film was removed, and development was carried out by spraying a 1.0% by weight aqueous sodium carbonate solution at 30°C. Here, the adhesive property was evaluated with the minimum value of the line width among the fine lines adhered to the substrate after the development. The smaller numerical value obtained by the adhesive property test means better results.

Thereafter, by using a comb-shaped pattern with 5  $\mu\text{m}$ , a resist pattern was prepared by the same manner as that of the adhesion property test, and resolution ( $\mu\text{m}$ ) was evaluated from the remaining resist pattern. The smaller numerical value obtained by the resolution test means better results.

Next, exposure was carried out with the above-mentioned energy dose and a line width/space width of 50  $\mu\text{m}$ /50  $\mu\text{m}$  followed by development, and the shape of the resulting resist pattern was observed by a scanning type electron microscope to evaluate the nick property on the side surface of the resist pattern. The nick property on the side surface of the resist pattern means the state in which the shape of the resist pattern is not plain and an unfavorable side surface is present on the side of the resist pattern. The unevenness due to the nick on the side surface of the resist pattern is preferably shallow.

Deep: The case where unevenness of the side surface's nick exceeds 2  $\mu\text{m}$ .

Shallow: The case where unevenness of the side surface's nick is not more than 2  $\mu\text{m}$ .

The results are shown in Table 2.

Also, the contact angles of the X surface (a surface to which the photosensitive resin composition is coated and dried) and the Y surface (a surface opposite to the surface to which the photosensitive resin composition is coated and dried) of the support films shown in Table 2 were measured according to JIS R 3257 and using a contact angle meter CA-A (trade name, available from Kyowa Kaimen Kagaku K.K., Japan, QI optical mirror system).

Table 2

		Example 1	Example 2	Comparative example 1	Comparative example 2	Comparative example 3
Support film		A2100-16	A4100-25	G2-16	G2-19	V-20
Thickness of support film ( $\mu\text{m}$ )		16	25	16	19	20
Haze (%)		0.2	0.8	2.2	2.5	5.5
Thermal shrinkage ratio (%)	Longitudinal direction	0.46	0.49	0.50	0.53	0.58
	150°C	1.35	1.51	2.00	2.33	2.39
	200°C	4.09	4.84	7.03	7.91	8.01
	Lateral direction	0.00	0.00	0.00	0.01	0.01
	105°C	0.01	0.18	0.92	0.98	0.95
	150°C	0.85	0.99	5.55	6.03	5.98
(Contact angle of X surface)/(Contact angle of Y surface)		>1.1	>1.1	$\leq 1.1$	$\leq 1.1$	$\leq 1.1$
Resolution ( $\mu\text{m}$ )		15	20	20	20	30
Adhesive property ( $\mu\text{m}$ )		15	15	20	20	25
Side wall flatness of a resist pattern		Shallow	Shallow	Deep	Deep	Deep

Example 3

The photosensitive element prepared in Example 1 was laminated on a copper-clad laminated board (MCL-E-61, trade name, available from Hitachi Chemical Co., Ltd.) which is a glass epoxy material on which copper foils (a thickness: 35  $\mu\text{m}$ ) had been laminated on the both surfaces thereof in the same manner as in Example 1. Next, exposure was carried out in the same manner as in Example 1 in such an energy dose that the number of remaining step after development became 8.0 by using a linear negative pattern (having an window which transmits active light with a size of 100  $\mu\text{m}$   $\times$  1 cm) as a negative material.

When the unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was measured by a Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan), the deepest unevenness was 0.9  $\mu\text{m}$ . Also, when a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface of the resulting resist pattern were measured (a cut-off value:  $\lambda_c=0.8$  mm, an evaluation length  $l_n=4$  mm) by the Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan), the results of  $R_a=0.3$   $\mu\text{m}$  and  $R_y=1.0$   $\mu\text{m}$  were obtained.

Example 4

A resist pattern was prepared in the same manner as in Example 3 except for using the photosensitive element prepared in Example 2 in place of that prepared in Example 1.

The deepest unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was 1.0  $\mu\text{m}$ . Also, a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface of the resulting resist pattern were  $R_a=0.4$   $\mu\text{m}$  and  $R_y=1.0$   $\mu\text{m}$ , respectively.

Comparative example 4

A resist pattern was prepared in the same manner as in Example 3 except for using the photosensitive element prepared in Comparative example 1 in place of that prepared in Example

1.

The deepest unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was 5.0  $\mu\text{m}$ , and the number of the unevenness larger than 3.0  $\mu\text{m}$  was 8. Also, a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface of the resulting resist pattern were  $R_a=2.3 \mu\text{m}$  and  $R_y=5.0 \mu\text{m}$ , respectively.

Comparative example 5

10 A resist pattern was prepared in the same manner as in Example 3 except for using the photosensitive element prepared in Comparative example 2 in place of that prepared in Example 1.

15 The deepest unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was 5.1  $\mu\text{m}$ , and the number of the unevenness larger than 3.0  $\mu\text{m}$  was 9. Also, a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface of the resulting resist pattern were  $R_a=2.2 \mu\text{m}$  and  $R_y=5.1 \mu\text{m}$ , respectively.

Comparative example 6

25 A resist pattern was prepared in the same manner as in Example 3 except for using the photosensitive element prepared in Comparative example 3 in place of that prepared in Example 1.

30 The deepest unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was 5.5  $\mu\text{m}$ , and the number of the unevenness larger than 3.0  $\mu\text{m}$  was 7. Also, a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface of the resulting resist pattern were  $R_a=2.3 \mu\text{m}$  and  $R_y=5.5 \mu\text{m}$ , respectively.

Example 5

35 The photosensitive element prepared in Example 1 was laminated on a copper-clad laminated board (MCL-E-61, trade name, available from Hitachi Chemical Co., Ltd.) which is a

glass epoxy material in which copper foils (a thickness: 35  $\mu\text{m}$ ) had been laminated on the both surfaces thereof in the same manner as in Example 1. Then, exposure of the resulting material was carried out in the same manner as in Example 1 in such a manner that a linear wiring pattern (a width: 100  $\mu\text{m}$ , a length: 1 cm, a height: a metal layer thickness of the substrate for forming a circuit) can be obtained with an energy dose that the number of remaining step after development became 8.0, followed by development and an etching treatment with a ferric chloride solution at 50°C.

When the unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was measured by a Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan), the deepest unevenness was 0.9  $\mu\text{m}$ . Also, when a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface of the resulting resist pattern were measured (a cut-off value:  $\lambda_c=0.8$  mm, an evaluation length  $l_n=4$  mm) by the Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan), the results of  $R_a=0.3$   $\mu\text{m}$  and  $R_y=0.9$   $\mu\text{m}$  were obtained.

The resulting wiring pattern had good appearance and electric resistant characteristics thereof were also good.  
Example 6

A resist pattern was prepared in the same manner as in Example 5 except for using the photosensitive element prepared in Example 2 in place of that prepared in Example 1.

The deepest unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was 1.0  $\mu\text{m}$ . Also, a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface of the resulting resist pattern were  $R_a=0.4$   $\mu\text{m}$  and  $R_y=1.0$   $\mu\text{m}$ , respectively.

The resulting wiring pattern had good appearance and electric resistant characteristics thereof were also good.  
Comparative example 7

A resist pattern was prepared in the same manner as in Example 5 except for using the photosensitive element prepared in Comparative example 1 in place of that prepared in Example 1.

5 The deepest unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was 5.0  $\mu\text{m}$ , and the number of the unevenness larger than 3.0  $\mu\text{m}$  was 8. Also, a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface  
10 of the resulting resist pattern were  $R_a=2.3 \mu\text{m}$  and  $R_y=5.0 \mu\text{m}$ , respectively.

The resulting wiring pattern was inferior in appearance to those obtained in Examples 5 and 6, and electric resistant characteristics thereof were also poor.

15 Comparative example 8

A resist pattern was prepared in the same manner as in Example 5 except for using the photosensitive element prepared in Comparative example 2 in place of that prepared in Example 1.

20 The deepest unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was 5.1  $\mu\text{m}$ , and the number of the unevenness larger than 3.0  $\mu\text{m}$  was 9. Also, a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface  
25 of the resulting resist pattern were  $R_a=2.2 \mu\text{m}$  and  $R_y=5.1 \mu\text{m}$ , respectively.

The resulting wiring pattern was inferior in appearance to those obtained in Examples 5 and 6, and electric resistant characteristics thereof were also poor.

30 Comparative example 9

A resist pattern was prepared in the same manner as in Example 5 except for using the photosensitive element prepared in Comparative example 3 in place of that prepared in Example 1.

35 The deepest unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was 5.5

μm, and the number of the unevenness larger than 3.0 μm was 7. Also, a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface of the resulting resist pattern were  $R_a=2.3$  μm and  $R_y=5.5$  μm, respectively.

The resulting wiring pattern was inferior in appearance to those obtained in Examples 5 and 6, and electric resistant characteristics thereof were also poor.

#### Example 7

A polyethylene film was laminated as a protective film on the photosensitive element obtained in Example 1, on the surface of a photosensitive resin composition layer, opposite to a support film. Next, the photosensitive element (a width: 55 cm, a length: 300 m) was wound around a core (a diameter: 8 cm, a length to the axis direction: 60 cm) so that the surface having the support film became outside to obtain a wound photosensitive element roll. The resulting photosensitive element roll was stored in an insulating container at 0°C for 10 hours.

After storage in the insulating container, the photosensitive element roll was dropped five times from the height of 10 cm to a concrete surface (a collision surface) so that the axis direction of the core became perpendicular to the collision surface. Incidentally, dropping was successively carried out five times within one minute.

A total height of winding deviation at the edge surface of the photosensitive element roll after five times dropping was 0.5 mm.

#### Example 8

The same experiment as in Example 7 was carried out except for using the photosensitive element prepared in Example 2 in place of that prepared in Example 1.

A total height of winding deviation at the edge surface of the photosensitive element roll after five times dropping was 0.6 mm.

Comparative example 10



The same experiment as in Example 7 was carried out except for using the photosensitive element prepared in Comparative example 1 in place of that prepared in Example 1.

5 of the photosensitive element roll after five times dropping was 5.0 mm.

Comparative example 11

10 The same experiment as in Example 7 was carried out except for using the photosensitive element prepared in Comparative example 2 in place of that prepared in Example 1.

A total height of winding deviation at the edge surface of the photosensitive element roll after five times dropping was 4.0 mm.

Comparative example 12

15 The same experiment as in Example 7 was carried out except for using the photosensitive element prepared in Comparative example 3 in place of that prepared in Example 1.

20 A total height of winding deviation at the edge surface of the photosensitive element roll after five times dropping was 6.0 mm.

#### Industrial Applicability

25 The photosensitive element of the present invention is excellent in side wall flatness of a resist pattern, flatness on an upper surface of the same, resolution, adhesiveness, alkaline developability, productivity and operatability, and having less number of mouse bites.

30 The photosensitive element of the present invention is excellent in side wall flatness of a resist pattern, in addition to the above effects.

The photosensitive element of the present invention is excellent in resolution, in addition to the above effects.

35 The photosensitive element of the present invention is excellent in dimensional stability at the time of lamination in addition to the above effects.

The photosensitive element of the present invention is

excellent in film strength after hardening the resist in addition to the above effects.

The photosensitive element of the present invention is excellent in peeling property in addition to the above effects.

5 The photosensitive element of the present invention is excellent in cold flow property at storage in addition to the above effects.

10 The photosensitive element roll of the present invention is excellent in side wall flatness of a resist pattern, flatness on an upper surface of the same, resolution, adhesiveness, alkaline developability, winding deviation during shipping, productivity and operatability, and having less number of mouse bites.

15 The photosensitive element roll of the present invention is excellent in side wall flatness of a resist pattern, flatness on an upper surface of the same, resolution, adhesiveness, winding deviation during shipping, productivity and operatability, and having less number of mouse bites.

20 The process for preparing a resist pattern of the present invention is excellent in side wall flatness of a resist pattern, flatness on an upper surface of the same, resolution, adhesiveness, productivity and operatability, and having less number of mouse bites.

25 The resist pattern of the present invention is excellent in side wall flatness of a resist pattern, flatness on an upper surface of the same, resolution, adhesiveness, productivity and operatability, and having less number of mouse bites.

30 The resist pattern laminated substrate of the present invention is excellent in side wall flatness of a resist pattern, flatness on an upper surface of the same, resolution, adhesiveness, productivity and operatability, and having less number of mouse bites.

35 The process for preparing a wiring pattern of the present invention is excellent in side wall flatness of a resist pattern, electric resistance and appearance of lines.

The wiring pattern of the present invention is excellent

in side wall flatness of a resist pattern, electric resistance and appearance of lines.

Claims

1. A photosensitive element comprising a support film which comprises a biaxially oriented polyester film and a  
5 photosensitive resin composition layer formed on one surface of the polyester film,

wherein a resin layer containing fine particles is formed on the opposite surface of the support film to which the photosensitive resin composition layer is formed, and said  
10 photosensitive resin composition comprises

- (A) a binder polymer having a carboxyl group,  
(B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule,  
and  
15 (C) a photopolymerization initiator.

2. A photosensitive element having a layer of a photosensitive resin composition on a support film, which comprises having a heat shrinkage ratio in the lateral direction of the support  
20 film at 200°C for 30 minutes being 0.00 to 4.00%, and said photosensitive resin composition comprises

- (A) a binder polymer having a carboxyl group,  
(B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule,  
25 and  
(C) a photopolymerization initiator.

3. The photosensitive element according to Claim 2, wherein the heat shrinkage ratio in the lateral direction of the support  
30 film at 150°C for 30 minutes is 0.00 to 0.20%.

4. The photosensitive element according to Claim 2, wherein the heat shrinkage ratio in the lateral direction of the support  
film at 105°C for 30 minutes is 0.00 to 0.20%.

- 35 5. A photosensitive element having a layer of a photosensitive

resin composition on a support film, which comprises having a heat shrinkage ratio in the lateral direction of the support film at 150°C for 30 minutes being 0.00 to 0.20%, and said photosensitive resin composition comprises

- 5 (A) a binder polymer having a carboxyl group,  
(B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and  
(C) a photopolymerization initiator.

10

6. The photosensitive element according to Claim 5, wherein the heat shrinkage ratio in the lateral direction of the support film at 105°C for 30 minutes is 0.00 to 0.20%.

- 15 7. A photosensitive element having a layer of a photosensitive resin composition on a support film, wherein a contact angle (°) of the support film with water satisfies the following numerical formula (1):

20 
$$\frac{(\text{Contact angle at X surface})}{(\text{Contact angle at Y surface})} > 1.1 \quad (1)$$
  
wherein X surface means a surface of the support film to which the photosensitive resin composition is coated and dried; and Y surface means a surface of the support film opposite to the surface to which the photosensitive resin  
25 composition is coated,

and said photosensitive resin composition comprises

- (A) a binder polymer having a carboxyl group,  
(B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and  
30 (C) a photopolymerization initiator.

8. The above photosensitive element according to Claim 2, wherein the support film is a support film comprising a resin  
35 layer containing fine particles being laminated on one surface of a biaxially oriented polyester film, and the photosensitive

resin composition layer is coated and dried on the opposite surface of the support film to which the resin layer is formed.

9. The photosensitive element according to Claim 1, wherein  
5 an average particle size of the fine particles is 0.01 to 5.0  $\mu\text{m}$ .

10. The photosensitive element according to Claim 1, wherein  
10 a thickness of the resin layer containing fine particles is 0.05 to 5.0  $\mu\text{m}$ .

11. The photosensitive element according to Claim 1, wherein  
a haze of the support film is 0.01 to 5.0%.

12. The photosensitive element according to Claim 1, wherein  
15 a heat shrinkage ratio in the longitudinal direction of the support film at 105°C for 30 minutes is 0.30 to 0.60%.

13. The photosensitive element according to Claim 1, wherein  
20 a heat shrinkage ratio in the longitudinal direction of the support film at 150°C for 30 minutes is 1.00 to 1.90%.

14. The photosensitive element according to Claim 1, wherein  
25 a heat shrinkage ratio in the longitudinal direction of the support film at 200°C for 30 minutes is 3.00 to 6.50%.

15. The photosensitive element according to Claim 1, wherein  
a weight average molecular weight of (A) the binder polymer having a carboxyl group is 20,000 to 300,000.

16. The photosensitive element according to Claim 1, wherein  
30 an acid value of (A) the binder polymer having a carboxyl group is 50 to 300 mg KOH/g.

17. The photosensitive element according to Claim 1, wherein  
35 (B) the photopolymerizable compound is a bisphenol A type

(meth)acrylate compound.

18. The photosensitive element according to Claim 1, wherein  
(C) the photopolymerization initiator is 2,4,5-triaryl  
5 imidazole dimer.

19. The photosensitive element according to Claim 1, wherein  
formulation amounts of Components (A), (B) and (C) are  
40 to 80 parts by weight of Component (A) based on 100 parts  
10 by weight of Component (A) and Component (B) in total,  
20 to 60 parts by weight of Component (B) based on 100 parts  
by weight of Component (A) and Component (B) in total, and  
0.01 to 20 parts by weight of Component (C) based on 100 parts  
by weight of Component (A) and Component (B) in total.

15 20. A photosensitive element roll according to any one of  
Claims 1 to 19, wherein the above photosensitive element is  
wound up or rolled around a core.

20 21. A photosensitive element roll in which the photosensitive  
element is wound up around a core, wherein a total height of  
winding deviation at the edge surface of the photosensitive  
element roll after naturally dropping the photosensitive  
element roll five times from the height of 10 cm to the collision  
25 surface so that the axis direction of the core becomes  
perpendicular to the collision surface is 1 mm or less.

22. A process for preparing a resist pattern which comprises  
laminating the photosensitive element according to any one of  
30 Claims 1 to 20 to a substrate for forming a circuit so that the  
photosensitive resin composition layer is closely contacted to  
the substrate, irradiating imagewisely active light to  
photocure the exposed portion, and removing an unexposed  
portion by development.

35 23. A resist pattern prepared by the preparation process

according to Claim 22.

24. A resist pattern in which unevenness on the side surface of the resist pattern is 0 to 3.0  $\mu\text{m}$ .

5

25. A resist pattern in which a number of unevenness larger than 3.0  $\mu\text{m}$  on the center line of the side surface of the resist pattern is 0 to 5/4 mm.

10 26. A resist pattern in which a mathematical average roughness ( $R_a$ ) on the side surface of the resist pattern is 0 to 2.0  $\mu\text{m}$ .

27. The resist pattern according to Claim 26, wherein a maximum height ( $R_y$ ) on the side surface of the resist pattern is 0 to 3.0  $\mu\text{m}$ .

15

28. A resist pattern comprising a maximum height ( $R_y$ ) on the side surface of the resist pattern of 0 to 3.0  $\mu\text{m}$ .

20 29. The resist pattern according to any one of Claims 24 to 28, wherein a width of the resist pattern is 1  $\mu\text{m}$  or more.

30. The resist pattern according to any one of Claims 24 to 28, wherein a height of the resist pattern is 1 to 150  $\mu\text{m}$ .

25

31. The resist pattern laminated substrate which comprises the resist pattern according to any one of Claims 24 to 28, wherein it is formed on a substrate for preparing a circuit.

30 32. A process for preparing a wiring pattern which comprises subjecting the resist pattern laminated substrate according to Claim 31 to etching or plating.

35 33. A wiring pattern prepared by the process for preparing the wiring pattern according to Claim 32.



34. A wiring pattern in which unevenness on the side surface of the wiring pattern is 0 to 3.0  $\mu\text{m}$ .

5 35. A wiring pattern in which a number of unevenness larger than 3.0  $\mu\text{m}$  on the center line of the side surface of the wiring pattern is 0 to 5/4 mm.

36. A wiring pattern in which a mathematical average roughness ( $R_a$ ) on the side surface of the wiring pattern is 0 to 2.0  $\mu\text{m}$ .

10

37. The wiring pattern according to Claim 36, wherein a maximum height ( $R_y$ ) on the side surface of the wiring pattern is 0 to 3.0  $\mu\text{m}$ .

15

38. A wiring pattern comprising a maximum height ( $R_y$ ) on the side surface of the wiring pattern of 0 to 3.0  $\mu\text{m}$ .

39. The wiring pattern according to any one of Claims 34 to 38, wherein a width of the wiring pattern is 1  $\mu\text{m}$  or more.

20

40. The wiring pattern according to any one of Claims 34 to 38, wherein a height of the wiring pattern is 0.01 to 200  $\mu\text{m}$ .

## Abstract

- There are disclosed a photosensitive element comprising a support film which comprises a biaxially oriented polyester film and a photosensitive resin composition layer formed on one surface of the polyester film,
- 5 wherein a resin layer containing fine particles is formed on the opposite surface of the support film to which the photosensitive resin composition layer is formed, and said
- 10 photosensitive resin composition comprises
- (A) a binder polymer having a carboxyl group,
- (B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and
- 15 (C) a photopolymerization initiator,
- a photosensitive element roll, a process for the preparation of a resist pattern using the same, the resist pattern, a resist pattern-laminated substrate, a process for the preparation of a wiring pattern and the wiring pattern.

Fig. 1

Axis direction

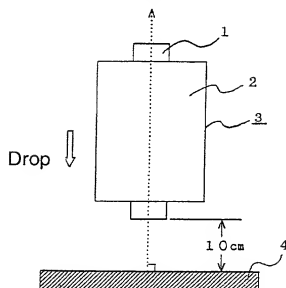


Fig. 2A

Axis direction

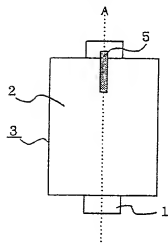


Fig. 2B

Axis direction

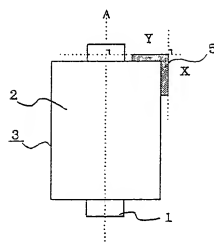


Fig. 3

Y piece

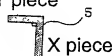


Fig. 4A  
Axis direction

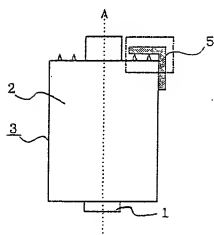


Fig. 4B

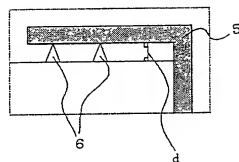


Fig. 5

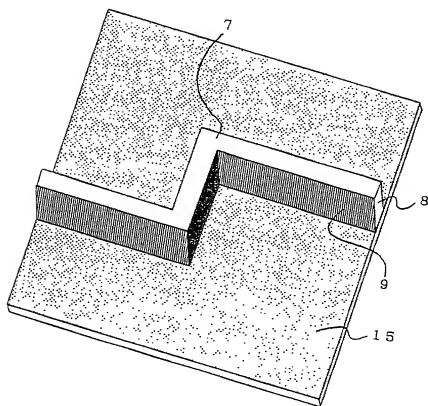


Fig. 6

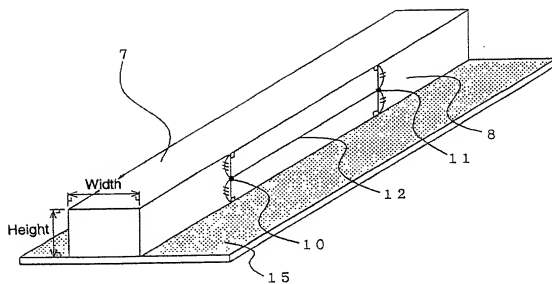


Fig. 7

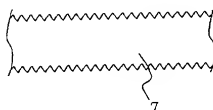
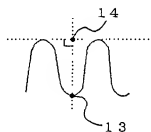


Fig. 8



FP2356PCT

## SPECIFICATION

PHOTOSENSITIVE ELEMENT, PHOTOSENSITIVE ELEMENT ROLL, PROCESS  
5 FOR THE PREPARATION OF RESIST PATTERN USING THE SAME, RESIST  
PATTERN, RESIST PATTERN LAMINATED SUBSTRATE, PROCESS FOR THE  
PREPARATION OF WIRING PATTERN AND WIRING PATTERN

## Technical field

10 This invention relates to a photosensitive element, a  
photosensitive element roll, a process for the preparation of  
a resist pattern using the same, the resist pattern, a resist  
pattern laminated substrate, a process for the preparation of  
a wiring pattern and the wiring pattern.

15 Prior art

In the field of a preparation of a printed wiring board,  
precision processing of a metal, etc., a photosensitive resin  
composition and a photosensitive element have been widely used  
20 as a resist material to be used for etching, plating, etc.

A photosensitive element generally comprises three  
layers of a light-transmissive support film, a photosensitive  
resin composition layer and a protective film. As a method of  
using the same, there may be mentioned a method in which a  
25 protective film is firstly peeled off, the element is bonded  
by pressure (laminated) so as to directly contact with a  
photosensitive resin layer, a negative film which has been  
subjected to patterning is adhered onto a light-transmissive  
film, active light (ultraviolet rays are frequently used) is  
30 irradiated (exposed), and then, unnecessary portions are  
removed by spraying an organic solvent or an aqueous alkaline  
solution to form (develop) a resist pattern. A method which  
employs an aqueous alkaline solution as a developing solution  
has been highly demanded in view of an environmental problem.

35 In recent years, electronic equipment has been promoted  
to be small sized and light weighted. A printed wiring board

has been also required to make the circuit fine, a resist pattern is made finer line and high resolution of a photosensitive element has been required. However, such demands cannot be satisfied by the conventional photosensitive element

5 comprising the three-layer structure. That is, it is exposed through a light-transmissive support film so that a thickness of the film is required to be thin as much as possible to obtain high resolution. On the other hand, the support is required to have a self-retaining property with a certain extent to  
10 accomplish a role as a support for a photosensitive resin composition to be coated. It is generally required to have a thickness of 15 to 25  $\mu\text{m}$ . Thus, it is the present status that the demand of high resolution cannot be accomplished when a light-transmissive support film with the conventional grade is  
15 used.

To these demands, various attempts have been made to accomplish high resolution. For example, there is a method in which a support film is peeled off before exposure and a negative film is directly adhered onto a photosensitive resin  
20 composition layer. In general, the photosensitive resin composition layer has an adhesive property with a certain extent so as to adhere to a substrate material. Thus, when the method is directly applied to, the negative film and the photosensitive resin composition layer are adhered whereby the problems arise  
25 that the negative film is difficultly peeled off so that operatability is lowered, the negative film is stained by the photosensitive resin or sensitivity is lowered due to inhibition by oxygen in air.

Thus, as an attempt to improve the above method, there  
30 has been proposed a method in which a photosensitive resin composition layer is provided with two or more layers and a layer directly contacting with the negative film is made non-adhesive layer (see Japanese Provisional Patent Publications (Kokai) No. Sho. 61-31855 (1986), No. Hei. 1-221735 (1989), No. Hei. 2-230149 (1990), etc.). However, this method requires  
35 troublesome operation to make a multi-layered photosensitive

resin composition layers and has no effect on sensitivity.

Also, as the other method, an attempt of providing an intermediate layer on the photosensitive resin composition layer to solve these problems has been described in, for example, Japanese Patent Publications (Kokoku) No. Sho. 54-12215 (1979) and Sho. 56-40824 (1981), Japanese Provisional Patent Publications No. Sho. 55-501072 (1980), No. Sho. 47-469 (1972), No. Sho. 59-97138 (1984), No. Sho. 59-216141 (1984) and No. Sho. 63-197942 (1988), etc. However, in either of these methods, an intermediate layer must be provided between a support film and a photosensitive resin composition layer so that coating must be carried out twice, and handling of a thin intermediate layer is difficult.

An object of the present invention is to provide a photosensitive element excellent in side wall flatness of a resist pattern, flatness at an upper surface of the same, resolution, adhesiveness, alkaline developability, productivity and operatability, and having less number of mouse bites.

An object of the present invention is to provide a photosensitive element excellent in side wall flatness of a resist pattern in addition to the above effects.

An object of the present invention is to provide a photosensitive element excellent in resolution in addition to the above effects.

Another object of the present invention is to provide a photosensitive element excellent in dimensional stability at the time of lamination in addition to the above effects.

Further object of the present invention is to provide a photosensitive element excellent in film strength after hardening the resist in addition to the above effects.

Still further object of the present invention is to provide a photosensitive element excellent in peeling property in addition to the above effects.

Still further object of the present invention is to provide a photosensitive element excellent in plating



resistance in addition to the above effects.

Still further object of the present invention is to provide a photosensitive element excellent in adhesiveness in addition to the above effects.

- 5 Still further object of the present invention is to provide a photosensitive element excellent in cold flow property at storage in addition to the above effects.

- 10 Another object of the present invention is to provide a photosensitive element roll excellent in side wall flatness of a resist pattern, flatness at an upper surface of the same, resolution, adhesiveness, winding deviation during shipping, productivity and operatability, and having less number of mouse bites.

- 15 A further object of the present invention is to provide a process for preparing a resist pattern excellent in side wall flatness of a resist pattern, flatness at an upper surface of the same, resolution, adhesiveness, productivity and operatability, and having less number of mouse bites.

- 20 A further object of the present invention is to provide a resist pattern excellent in side wall flatness of a resist pattern, flatness at an upper surface of the same, resolution, adhesiveness, productivity and operatability, and having less number of mouse bites.

- 25 A further object of the present invention is to provide a resist pattern laminated substrate excellent in side wall flatness of a resist pattern, flatness at an upper surface of the same, resolution, adhesiveness, winding deviation at transfer, productivity and operatability, and less number of mouse bites.

- 30 A further object of the present invention is to provide a process for preparing a wiring pattern excellent in side wall flatness of a resist pattern, electric resistance and appearance of lines.

- 35 A further object of the present invention is to provide a wiring pattern excellent in side wall flatness of a resist pattern, electric resistance and appearance of lines.

Disclosure of the invention

The present invention relates to a photosensitive element comprising a support film which comprises a biaxially oriented polyester film and a photosensitive resin composition layer  
5 formed on one surface of the polyester film, wherein a resin layer containing fine particles is formed on the opposite surface of the support film to which the photosensitive resin composition layer is formed, and said photosensitive resin composition comprises

- 10 (A) a binder polymer having a carboxyl group,  
(B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and  
(C) a photopolymerization initiator.

15 Also, the present invention relates to a photosensitive element having a layer of a photosensitive resin composition on a support film, which comprises having a heat shrinkage ratio to the lateral direction of the support film at 200°C for 30 minutes being 0.00 to 4.00% and said photosensitive resin  
20 composition comprises

- (A) a binder polymer having a carboxyl group,  
(B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and  
25 (C) a photopolymerization initiator.

The present invention also relates to the above photosensitive element in which the heat shrinkage ratio to the lateral direction of the support film at 150°C for 30 minutes is 0.00 to 0.20%.

30 The present invention also relates to the above photosensitive element in which the heat shrinkage ratio to the lateral direction of the support film at 105°C for 30 minutes is 0.00 to 0.20%.

35 Also, the present invention relates to a photosensitive element having a layer of a photosensitive resin composition on a support film, which comprises having a heat shrinkage ratio

to the lateral direction of the support film at 150°C for 30 minutes being 0.00 to 0.20% and said photosensitive resin composition comprises

- (A) a binder polymer having a carboxyl group,
- 5 (B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and
- (C) a photopolymerization initiator.

The present invention also relates to the above  
10 photosensitive element in which the heat shrinkage ratio to the lateral direction of the support film at 105°C for 30 minutes is 0.00 to 0.20%.

Moreover, the present invention relates to a photo-sensitive element having a layer of a photosensitive resin  
15 composition on a support film, which comprises having a contact angle (°) of the support film by water satisfying the following numerical formula (1):

$$\frac{(\text{Contact angle at X surface})}{(\text{Contact angle at Y surface})} > 1.1 \quad (1)$$

20 X surface: a surface of the support film to which the photosensitive resin composition is coated and dried,  
Y surface: a surface of the support film opposite to the surface to which the photosensitive resin composition is coated,

- 25 and said photosensitive resin composition comprises
- (A) a binder polymer having a carboxyl group,
  - (B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and
  - 30 (C) a photopolymerization initiator.

Furthermore, the present invention relates to the above photosensitive element in which the support film is a support film comprising a resin layer containing fine particles being  
35 laminated on one surface of a biaxially oriented polyester film, and the photosensitive resin composition layer is provided at the opposite surface of the support film to which the resin layer

is formed.

The present invention also relates to the above photosensitive element in which an average particle size of the fine particles is 0.01 to 5.0  $\mu\text{m}$ .

5 The present invention also relates to the above photosensitive element in which a thickness of the resin layer containing fine particles is 0.05 to 5.0  $\mu\text{m}$ .

The present invention also relates to the above photosensitive element in which a haze of the support film is  
10 0.01 to 5.0%.

The present invention also relates to the above photosensitive element in which a heat shrinkage ratio in the longitudinal direction of the support film at 105°C for 30 minutes is 0.30 to 0.60%.

15 The present invention also relates to the above photosensitive element in which a heat shrinkage ratio in the longitudinal direction of the support film at 150°C for 30 minutes is 1.00 to 1.90%.

The present invention also relates to the above  
20 photosensitive element in which a heat shrinkage ratio in the longitudinal direction of the support film at 200°C for 30 minutes is 3.00 to 6.50%.

The present invention also relates to the above photosensitive element in which a weight average molecular  
25 weight of (A) the binder polymer having a carboxyl group is 20,000 to 300,000.

The present invention also relates to the above photosensitive element in which an acid value of (A) the binder polymer having a carboxyl group is 50 to 300 mg KOH/g.

30 The present invention also relates to the above photosensitive element in which (B) the photopolymerizable compound is a bisphenol A type (meth)acrylate compound.

The present invention also relates to the above photosensitive element in which (C) the photopolymerization  
35 initiator is 2,4,5-triaryl imidazole dimer.

The present invention also relates to the above

photosensitive element in which formulation amounts of Components (A), (B) and (C) are

40 to 80 parts by weight of Component (A) based on 100 parts by weight of Component (A) and Component (B) in total,

- 5 20 to 60 parts by weight of Component (B) based on 100 parts by weight of Component (A) and Component (B) in total, and 0.01 to 20 parts by weight of Component (C) based on 100 parts by weight of Component (A) and Component (B) in total.

- 10 Moreover, the present invention relates to a photosensitive element roll in which the above photosensitive element is wound up or rolled around a core.

- 15 The present invention also relates to a photosensitive element roll in which the photosensitive element is wound up around a core, wherein a total height of winding deviation at the edge surface of the photosensitive element roll after naturally dropping the photosensitive element roll five times from the height of 10 cm to the collision surface so that the axis direction of the core becomes perpendicular to the collision surface is 1 mm or less.

- 20 The present invention also relates to a process for preparing a resist pattern which comprises laminating the above photosensitive element to a substrate for forming a circuit so that the photosensitive resin composition layer is closely contacted to the substrate, irradiating imagewise active light to photocure the exposed portion, and removing an unexposed portion by development.

The present invention also relates to a resist pattern prepared by the above preparation process.

- 30 The present invention also relates to the above resist pattern in which unevenness on the side surface of the resist pattern is 0 to 3.0  $\mu\text{m}$ .

- 35 The present invention also relates to the above resist pattern in which a number of unevenness larger than 3.0  $\mu\text{m}$  on the center line of the side surface of the resist pattern is 0 to 5/4 mm.

The present invention also relates to the above resist

pattern in which a mathematical average roughness ( $R_a$ ) on the side surface of the resist pattern is 0 to 2.0  $\mu\text{m}$ .

5 The present invention also relates to the above resist pattern in which a maximum height ( $R_y$ ) on the side surface of the resist pattern is 0 to 3.0  $\mu\text{m}$ .

The present invention also relates to a resist pattern comprising a maximum height ( $R_y$ ) on the side surface of the resist pattern of 0 to 3.0  $\mu\text{m}$ .

10 The present invention also relates to the above resist pattern in which a width of the resist pattern is 1  $\mu\text{m}$  or more.

The present invention also relates to the above resist pattern in which a height of the resist pattern is 1 to 150  $\mu\text{m}$ .

15 The present invention also relates to a resist pattern laminated substrate which comprises the above resist pattern being formed on a substrate for preparing a circuit.

The present invention also relates to a process for preparing a wiring pattern which comprises subjecting the above resist pattern laminated substrate to etching or plating.

20 The present invention also relates to a wiring pattern prepared by the above process for preparing the wiring pattern.

The present invention also relates to the above wiring pattern in which unevenness on the side surface of the wiring pattern is 0 to 3.0  $\mu\text{m}$ .

25 The present invention also relates to the above wiring pattern in which a number of unevenness larger than 3.0  $\mu\text{m}$  on the center line of the side surface of the wiring pattern is 0 to 5/4 mm.

30 The present invention also relates to the above wiring pattern in which a mathematical average roughness ( $R_a$ ) on the side surface of the wiring pattern is 0 to 2.0  $\mu\text{m}$ .

The present invention also relates to the above wiring pattern in which a maximum height ( $R_y$ ) on the side surface of the wiring pattern is 0 to 3.0  $\mu\text{m}$ .

35 The present invention also relates to a wiring pattern comprising a maximum height ( $R_y$ ) on the side surface of the wiring pattern of 0 to 3.0  $\mu\text{m}$ .

The present invention also relates to the above wiring pattern in which a width of the wiring pattern is 1  $\mu\text{m}$  or more.

The present invention also relates to the above wiring pattern in which a height of the wiring pattern is 0.01 to 200  $\mu\text{m}$ .

#### Brief description of the drawings

Fig. 1 is a schematic drawing showing a test method of winding deviation of a photosensitive element roll.

Fig. 2A and 2B are schematic drawings showing a method for measuring a height of winding deviation of a photosensitive element roll.

Fig. 3 is a schematic drawing showing an L-square.

Fig. 4A is a schematic drawing showing winding deviation-occurred portion of a photosensitive element roll and Fig. 4B is an enlarged partial view thereof.

Fig. 5 is a schematic drawing showing a resist pattern.

Fig. 6 is a schematic drawing showing a measurement method of a concavo-convex portion on the side surface of a resist pattern.

Fig. 7 is a sectional view of a resist pattern.

Fig. 8 is a sectional view of concave-convex portion on the side surface of a resist pattern.

#### Best mode for carrying out the invention

In the following, the present invention is explained in detail. Incidentally, a (meth)acrylic acid in the present specification means acrylic acid and methacrylic acid corresponding to the same, a (meth)acrylate means an acrylate and a methacrylate corresponding to the same, and a (meth)-acryloyl group means an acryloyl group and a methacryloyl group corresponding to the same.

The photosensitive element of the present invention has four aspects.

The first aspect of the photosensitive element of the present invention resides in a photosensitive element com-

prising a support film which comprises a biaxially oriented polyester film and a resin layer containing fine particles on one surface of the film, and a layer of a photosensitive resin composition formed on the opposite surface of the support film to which the resin layer is formed, and said photosensitive resin composition comprises (A) a binder polymer having a carboxyl group, (B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and (C) a photopolymerization initiator.

The second aspect of the photosensitive element of the present invention resides in a photosensitive element having a layer of a photosensitive resin composition on a support film, which comprises having a heat shrinkage ratio in the lateral direction of the support film at 200°C for 30 minutes being 0.00 to 4.00% and said photosensitive resin composition comprises (A) a binder polymer having a carboxyl group, (B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and (C) a photopolymerization initiator.

The third aspect of the photosensitive element of the present invention resides in a photosensitive element having a layer of a photosensitive resin composition on a support film, which comprises having a heat shrinkage ratio in the lateral direction of the support film at 150°C for 30 minutes being 0.00 to 0.20% and said photosensitive resin composition comprises (A) a binder polymer having a carboxyl group, (B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and (C) a photopolymerization initiator.

The fourth aspect of the photosensitive element of the present invention resides in a photosensitive element having a layer of a photosensitive resin composition on a support film, which comprises having a contact angle (°) of the support film with water satisfying the above numerical formula (2), and said photosensitive resin composition comprises (A) a binder polymer having a carboxyl group, (B) a photopolymerizable compound



having at least one polymerizable ethylenically unsaturated group in the molecule, and (C) a photopolymerization initiator.

The support film in the first aspect of the photosensitive element of the present invention comprises a resin layer  
5 containing fine particles laminated on one surface of a biaxially oriented polyester film. It is preferred that the second photosensitive element, third photosensitive element and fourth photosensitive element use the support film having the above-mentioned structure.

10 An average particle size of the above fine particles is preferably 0.01 to 5.0  $\mu\text{m}$ , more preferably 0.02 to 4.0  $\mu\text{m}$ , and particularly preferably 0.03 to 3.0  $\mu\text{m}$ . If the average particle size is less than 0.01  $\mu\text{m}$ , workability tends to be lowered, while if it exceeds 5.0  $\mu\text{m}$ , resolution and sensitivity tend to be  
15 lowered.

A formulating amount of the above fine particles may vary depending on, for example, a kind of a base resin constituting the resin layer, a kind and an average particle size of the fine particles, physical properties of the support film to be  
20 obtained, etc.

As the above fine particles, there may be mentioned inorganic particles such as silica, kaolin, talc, alumina, calcium phosphate, titanium dioxide, calcium carbonate, barium sulfate, calcium fluoride, lithium fluoride, zeolite,  
25 molybdenum sulfide, etc.; organic particles such as cross-linked polymer particles, calcium oxalate, etc. In view of transparency, particles of silica are preferred. These fine particles may be used singly or in combination of two or more.

As the base resin to constitute the resin layer containing  
30 the above-mentioned fine particles, there may be mentioned, for example, a polyester type resin, a polyurethane type resin, an acrylic type resin, a mixture thereof, a copolymer thereof, etc.

A thickness of the resin layer is preferably 0.01 to 5.0  $\mu\text{m}$ , more preferably 0.05 to 3.0  $\mu\text{m}$ , particularly preferably 0.1  
35 to 2.0  $\mu\text{m}$ , extremely preferably 0.1 to 1.0  $\mu\text{m}$ . If the thickness is less than 0.01  $\mu\text{m}$ , the effects of the present invention cannot

likely be obtained, while if it exceeds 5.0  $\mu\text{m}$ , transparency of the polyester film is poor, and sensitivity and resolution tend to be lowered.

5 The method of laminating the above resin layer on one surface of the above biaxially oriented polyester film is not particularly limited, and may be mentioned, for example, a coating method, etc.

10 The polyester type resin constituting the above biaxially oriented polyester film may include, for example, aromatic linear polyester comprising an aromatic dicarboxylic acid and a diol as constitutional components, such as polyethylene terephthalate, polybutylene terephthalate, polyethylene naphthalate, etc.; aliphatic linear polyester comprising an aliphatic dicarboxylic acid and a diol as constitutional  
15 components; a polyester type resin mainly comprising polyester such as a copolymer of the above materials; etc. These resins may be used singly or in combination of two or more.

20 Fine particles may be added to the biaxially oriented polyester film to which the above resin layer is laminated. As the fine particles, there may be mentioned, for example, the same fine particles to be contained in the above resin layer. A content thereof is preferably 0 to 80 ppm, more preferably 0 to 60 ppm, particularly preferably 0 to 40 ppm. If the content thereof exceeds 80 ppm, transparency of the polyester film is  
25 lowered as a whole, and resolution and sensitivity tend to be lowered.

A method for preparing the above biaxially oriented polyester film is not particularly limited, and there may be used, for example, a biaxially stretching method, etc. Also,  
30 after forming the above resin layer on one surface of an unstretched film or a mono-axially stretched film, and the film is further stretched to make a support film.

A thickness of the above biaxially stretched polyester film is preferably 1 to 100  $\mu\text{m}$ , more preferably 1 to 50  $\mu\text{m}$ ,  
35 particularly preferably 1 to 30  $\mu\text{m}$ , and extremely preferably 10 to 30  $\mu\text{m}$ . If the thickness is less than 1  $\mu\text{m}$ , preparation

of the film is not easy and the film cannot easily be commercially available, while if it exceeds 100  $\mu\text{m}$ , cheapness tends to be lowered.

5 The support film in the second aspect of the photo-sensitive element of the present invention has a heat shrinkage ratio in the lateral direction of the support film at 200°C for 30 minutes of 0.00 to 4.00%. It is preferred that the first photosensitive element, the third photosensitive element and the fourth photosensitive element use the support film having  
10 the heat shrinkage ratio within the above range.

The heat shrinkage ratio in the lateral direction of the above support film at 200°C for 30 minutes is required to be 0.00 to 4.00%, preferably 0.00 to 3.00%, more preferably 0.00 to 2.00%, particularly preferably 0.00 to 1.50%, extremely  
15 preferably 0.00 to 1.30%, most extremely preferably 0.00 to 1.00%. If the heat shrinkage ratio exceeds 4.00%, dimensional precision tends to be lowered.

The support film in the third aspect of the photosensitive element of the present invention has a heat shrinkage ratio in the lateral direction of the support film at 150°C for 30 minutes  
20 of 0.00 to 0.20%. It is preferred that the first photosensitive element, the second photosensitive element and the fourth photosensitive element use the support film having the heat shrinkage ratio within the above range.

25 The heat shrinkage ratio in the lateral direction of the above support film at 150°C for 30 minutes is required to be 0.00 to 0.20%, preferably 0.00 to 0.15%, more preferably 0.00 to 0.10 %, particularly preferably 0.00 to 0.05%, extremely preferably 0.00 to 0.04%, most extremely preferably 0.00 to 0.03%. If the heat shrinkage ratio exceeds 0.20%, dimensional  
30 precision tends to be lowered.

A haze of the above support film is preferably 0.01 to 5.0%, more preferably 0.01 to 3.0%, particularly preferably 0.01 to 2.0%, extremely preferably 0.01 to 1.0%. If the haze  
35 is less than 0.01%, preparation of the film is not easy, while if it exceeds 5.0%, sensitivity and resolution tend to be

lowered. Incidentally, the haze in the present invention is measured according to JIS K 7105 and, for example, measurement can be carried out by using a commercially available turbidimeter such as NDH-1001DP (available from Nippon Denshoku Kogyo K.K., Japan, trade name), etc.

The heat shrinkage ratio in the lateral direction of the above support film at 105°C for 30 minutes is 0.00 to 0.20%, more preferably 0.00 to 0.15%, particularly preferably 0.00 to 0.10%, extremely preferably 0.00 to 0.05%. If the heat shrinkage ratio exceeds 0.20%, dimensional precision tends to be lowered.

The support film in the fourth aspect of the photo-sensitive element of the present invention is preferably a support film satisfying the relationship between the contact angle of X surface (the surface of the support film to which the photosensitive resin composition is coated and dried) of the support film and the contact angle of Y surface (the surface of the support film opposite to the surface to which the photosensitive resin composition is coated and dried), of  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface}) > 1.1$ . It is preferred that the first photosensitive element, the second photosensitive element and the third photosensitive element use the support film satisfying the above relationship of contact angles.

The relationship of the contact angles of the above support film is required to be  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface}) > 1.1$ , preferably  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface}) > 1.15$ , more preferably  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface}) > 1.2$ , particularly preferably  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface}) > 1.25$ , most preferably  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface}) > 1.3$ , extremely preferably  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface}) > 1.35$ , most extremely preferably  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface}) > 1.4$ . Also, as the upper limit of  $(\text{Contact angle of X surface}) / (\text{Contact angle of Y surface})$ , it is preferably 5.0, more preferably 4.0,

particularly preferably 3.0, extremely preferably 2.0. If the relationship of the contact angles is less than 1.1, dimensional precision tends to be lowered. Incidentally, the contact angles in the present specification can be measured according to JIS R 3257 and measured by a static dropping method.

The heat shrinkage ratio in the longitudinal direction of the above support film at 105°C for 30 minutes is preferably 0.30 to 0.60%, more preferably 0.35 to 0.55%, particularly preferably 0.40 to 0.50 %. If the heat shrinkage ratio is less than 0.30%, the polyester film tends to be brittle, while if it exceeds 0.60%, dimensional change of the photosensitive element tends to be occurred at the time of lamination.

The heat shrinkage ratio in the longitudinal direction of the above support film at 150°C for 30 minutes is preferably 1.00 to 1.90%, more preferably 1.10 to 1.70%, particularly preferably 1.20 to 1.60 %. If the heat shrinkage ratio is less than 1.00%, the polyester film tends to be brittle, while if it exceeds 1.90%, dimensional change of the photosensitive element tends to be occurred at the time of lamination.

The heat shrinkage ratio to the longitudinal direction of the above support film at 200°C for 30 minutes is preferably 3.00 to 6.50%, more preferably 3.30 to 5.00%, particularly preferably 3.60 to 4.70 %. If the heat shrinkage ratio is less than 3.00%, the polyester film tends to be brittle, while if it exceeds 6.50%, dimensional change of the photosensitive element tends to be occurred at the time of lamination.

The heat shrinkage ratio of the present invention can be measured as mentioned below. Test pieces each having a width of 20 mm and a length of 150 mm were cut out along with the longitudinal direction and the lateral direction of the film, 5 pieces per each, and gage points are marked at the center portion of the respective test pieces with a distance of about 100 mm. The test pieces are vertically hanged in a thermostat with internal air circulation maintained at the above temperature  $\pm 3^{\circ}\text{C}$  for 30 minutes, taken out and allowed to stand at room temperature for 30 minutes, and the distance between

the gage points is measured. The heat shrinkage ratio is calculated according to following scheme (2) and an average thereof is obtained whereby the value can be obtained.

Incidentally, other regulations are according to JIS C2318-5 1997 (5.3.4 Dimensional change).

$$\Delta L(\%) = (L_0 - L) / L_0 \times 100 \quad (2)$$

$\Delta L$ : a heat shrinkage ratio (%),

$L_0$ : a distance (mm) between gage points before heating,

$L$ : a distance (mm) between gage points after heating.

10 As a commercially available support film, there may be mentioned, for example, A2100-16, A4100-25 (both trade names) available from Toyo Boseki K.K., Japan, etc.

A thickness of the above support film is preferably 1 to 100  $\mu\text{m}$ , more preferably 1 to 50  $\mu\text{m}$ , particularly preferably 1 to 30  $\mu\text{m}$ , extremely preferably 10 to 30  $\mu\text{m}$ . If the thickness is less than 1  $\mu\text{m}$ , mechanical strength tends to be lowered and a polymer film tends to be torn at the time of coating, while if it exceeds 100  $\mu\text{m}$ , resolution tends to be lowered and a cost tends to be expensive.

20 The photosensitive element of the first aspect of the present invention can be obtained by using a support film comprising a polyester film in which a resin layer containing fine particles is laminated on one surface of a biaxially oriented polyester film, coating a photosensitive resin composition on the other surface of the support opposed to the surface to which the above resin layer is formed, and drying the same. The above coating can be carried out by the conventionally known method by using a roll coater, a comma coater, a gravure coater, an air knife coater, a die coater, a bar coater, etc. Drying can be carried out at 80 to 150°C for about 5 to 30 minutes.

Also, the photosensitive element of the second aspect and the photosensitive element of the third aspect of the present invention can be obtained, for example, when a resin layer containing fine particles is present on one surface of the above support film depending on necessity, a layer of the photo-

sensitive resin composition is provided by coating on the surface opposite to the surface to which the above resin layer is provided, and drying. The above coating and drying may be mentioned the same ones as those mentioned in the photosensitive element of the first aspect.

(A) The binder polymer having a carboxyl group of the present invention can be produced, for example, by subjecting a polymerizable monomer having a carboxyl group and other polymerizable monomer to radical polymerization.

10 The polymerizable monomer having a carboxyl group may include, for example, (meth)acrylic acid,  $\alpha$ -bromo(meth)acrylic acid,  $\alpha$ -chloro(meth)acrylic acid,  $\beta$ -furyl(meth)acrylic acid,  $\beta$ -styryl(meth)acrylic acid, maleic acid, maleic anhydride, maleic acid monoester such as monomethyl maleate, monoethyl  
15 maleate, monoisopropyl maleate, etc., fumaric acid, cinnamic acid,  $\alpha$ -cyanocinnamic acid, itaconic acid, crotonic acid, propiolic acid, etc.

The other polymerizable monomer is not specifically limited, and may include, for example, styrene, a styrene  
20 derivative in which  $\alpha$ -position or aromatic ring is substituted by a substituent(s) such as vinyl toluene,  $\alpha$ -methylstyrene, etc., acrylamide such as diacetoneacrylamide, etc., acrylonitrile, an ester of vinyl alcohol such as vinyl-n-butyl ether, etc., alkyl (meth)acrylate, tetrahydrofurfuryl  
25 (meth)acrylate, dimethylaminoethyl (meth)acrylate, diethylaminoethyl (meth)acrylate, glycidyl (meth)acrylate, 2,2,2-trifluoroethyl (meth)acrylate, 2,2,3,3-tetrafluoropropyl (meth)acrylate, etc.

As the above alkyl (meth)acrylate, there may be mentioned,  
30 for example, a compound represented by the following formula (I):



wherein  $\text{R}^1$  represents a hydrogen atom or a methyl group;  
and  $\text{R}^2$  represents an alkyl group having 1 to 12 carbon

atoms,

a compound in which a hydroxyl group, an epoxy group, a halogen group, etc. is substituted at the alkyl group of the above-mentioned compound, or the like.

5 As the alkyl group having 1 to 12 carbon atoms of  $R^2$  in the above formula (I), there may be mentioned, for example, a methyl group, an ethyl group, a propyl group, a butyl group, a pentyl group, a hexyl group, a heptyl group, an octyl group, a nonyl group, a decyl group, an undecyl group, a dodecyl group  
10 and a structural isomer of these groups.

As a monomer represented by the above formula (I), there may be mentioned, for example, methyl (meth)acrylate, ethyl (meth)acrylate, propyl (meth)acrylate, butyl (meth)acrylate, pentyl (meth)acrylate, hexyl (meth)acrylate, heptyl (meth)-  
15 acrylate, octyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, nonyl (meth)acrylate, decyl (meth)acrylate, undecyl (meth)-acrylate, dodecyl (meth)acrylate, etc. These monomers may be used singly or in combination of two or more.

Also, in the binder polymer which is Component (A) of the  
20 present invention, styrene or styrene derivative may be preferably contained as a polymerizable monomer in view of flexibility of the resulting material.

The styrene or styrene derivative is preferably contained in an amount of 0.1 to 30% by weight as a copolymerizable  
25 component to make adhesive property and peeling property good, more preferably 1 to 28% by weight, particularly preferably 1.5 to 27% by weight. If the amount is less than 0.1% by weight, adhesive property tends to be lowered, while if it exceeds 30% by weight, a size of peeled pieces becomes large and a peeling  
30 time tends to be long.

These binder polymers may be used singly or in combination of two or more. When the binder polymer is used in combination of two or more, there may be mentioned, for example, two or more binder polymers comprising different copolymer components, two  
35 or more binder polymers having different weight average molecular weights, two or more binder polymers having different



dispersibilities, etc.

(A) The binder polymer having a carboxyl group according to the present invention preferably has a weight average molecular weight of 20,000 to 300,000 in view of film-forming property and resolution, more preferably 25,000 to 200,000, particularly preferably 30,000 to 150,000. If the weight average molecular weight is less than 20,000, developing solution resistance tends to be lowered, while if it exceeds 300,000, a developing time tends to be long. Incidentally, in the present specification, the weight average molecular weight is measured by using gel permeation chromatography and calculated by using a calibration curve of standard polystyrenes.

An acid value of (A) the binder polymer having a carboxyl group according to the present invention is preferably 50 to 300 mg KOH/g, more preferably 60 to 250 mg KOH/g, particularly preferably 70 to 200 mg KOH/g. If the acid value is less than 50 mg KOH/g, a developing time tends to be long, while if it exceeds 300 mg KOH/g, developing solution resistance of the photocured resist tends to be lowered.

(B) The photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule according to the present invention may include, for example, a compound obtained by reacting a polyvalent alcohol with an  $\alpha,\beta$ -unsaturated carboxylic acid; a bisphenol A type (meth)acrylate compound such as 2,2-bis(4-((meth)acryloxypolyethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxypolypropoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxypolyethoxypolypropoxy)phenyl)propane, etc.; a compound obtained by reacting a glycidyl group-containing compound with an  $\alpha,\beta$ -unsaturated carboxylic acid; a urethane monomer such as a (meth)acrylate compound having a urethane bond, etc.; nonylphenyldioxy (meth)acrylate,  $\gamma$ -chloro- $\beta$ -hydroxypropyl- $\beta'$ -(meth)acryloyloxyethyl-o-phthalate,  $\beta$ -hydroxyethyl- $\beta'$ -(meth)acryloyloxyethyl-o-phthalate,  $\beta$ -hydroxypropyl- $\beta'$ -(meth)acryloyloxyethyl-o-phthalate, alkyl

(meth)acrylate, etc., and it is preferred that the compound contains the bisphenol A type (meth)acrylate compound or the (meth)acrylate compound having a urethane bond as an essential component. These compounds may be used singly or in combination of two or more.

As the above-mentioned compound obtained by reacting the polyvalent alcohol with the  $\alpha,\beta$ -unsaturated carboxylic acid, there may be mentioned, for example, polyethyleneglycol di(meth)acrylate in which a number of the ethylene group is 2 to 14, polypropyleneglycol di(meth)acrylate in which a number of the propylene group is 2 to 14, trimethylolpropanedi(meth)acrylate, trimethylolpropanetri(meth)acrylate, trimethylolpropaneethoxytri(meth)acrylate, trimethylolpropanediethoxytri(meth)acrylate, trimethylolpropanetriethoxytri(meth)acrylate, trimethylolpropanetetraethoxytri(meth)acrylate, trimethylolpropanepentaethoxytri(meth)acrylate, tetramethylolmethanetri(meth)acrylate, tetramethylolmethanetetra(meth)acrylate, polypropyleneglycol di(meth)acrylate in which a number of the propylene group is 2 to 14, dipentaerythritolpenta(meth)acrylate, dipentaerythritolhexa(meth)acrylate, etc.

As the above  $\alpha,\beta$ -unsaturated carboxylic acid, there may be mentioned, for example, (meth)acrylic acid, etc.

As the above 2,2-bis(4-((meth)acryloxypolyethoxy)-phenyl)propane, there may be mentioned, for example, 2,2-bis(4-((meth)acryloxydiethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxytriethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxytetraethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxy-pentaethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxy-hexaethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxyheptaethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxyoctaethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxynonaethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxydecaethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxyundecaethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxydodecaethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxytrideca-

ethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxytetradecaethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxy-pentadecaethoxy)phenyl)propane, 2,2-bis(4-((meth)acryloxyhexadecaethoxy)phenyl)propane, etc. Of these, 2,2-bis(4-((meth)-  
5 acryloxy-pentaethoxy)phenyl)propane is commercially available as BPE-500 (trade name, available from Shin-Nakamura Kagaku Kogyo K.K., Japan), and 2,2-bis(4-((meth)acryloxy-pentadecaethoxy)phenyl)propane is commercially available as BPE-1300 (trade name, available from Shin-Nakamura Kagaku Kogyo K.K.,  
10 Japan). These compounds may be used singly or in combination of two or more.

As the above 2,2-bis(4-((meth)acryloxy-polyethoxy-polypropoxy)phenyl)propane, there may be mentioned, for example, 2,2-bis(4-((meth)acryloxydiethoxyoctapropoxy)phenyl)propane,  
15 2,2-bis(4-((meth)acryloxytetraethoxytetrapropoxy)phenyl)-propane, 2,2-bis(4-((meth)acryloxyhexaethoxyhexapropoxy)-phenyl)propane, etc. These compounds may be used singly or in combination of two or more.

As the above glycidyl group-containing compound, there  
20 may be mentioned, for example, trimethylolpropanetri-glycidyl ether tri(meth)acrylate, 2,2-bis(4-(meth)acryloxy-2-hydroxy-propyloxy)phenyl, etc.

As the above urethane monomer, there may be mentioned, for example, an addition reaction product of a (meth)acryl  
25 monomer having a OH group at the  $\beta$ -position and a diisocyanate compound such as isophorone diisocyanate, 2,6-tolylene diisocyanate, 2,4-tolylene diisocyanate, 1,6-hexamethylene diisocyanate, etc.; tris((meth)acryloxytetraethylene glycol isocyanate)hexamethylene isocyanurate, EO-modified urethane  
30 di(meth)acrylate, EO and PO-modified urethane di(meth)-acrylate, etc. Incidentally, EO represents ethylene oxide and the EO-modified compound has a block structure of an ethylene oxide group. Also, PO represents propylene oxide and the PO-modified compound has a block structure of a propylene oxide  
35 group.

As the EO-modified urethane di(meth)acrylate, there may

be mentioned, for example, UA-11 (trade name, available from Shin-Nakamura Kagaku Kogyo K.K., Japan), etc. Also, the EO and PO-modified urethane di(meth)acrylate, there may be mentioned, for example, UA-13 (trade name, available from Shin-Nakamura Kagaku Kogyo K.K., Japan), etc.

As the above alkyl (meth)acrylate, there may be mentioned, for example, methyl (meth)acrylate, ethyl (meth)acrylate, butyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, etc.

These compounds may be used singly or in combination of two or more.

(C) The photopolymerization initiator in the present invention may include, for example, aromatic ketones such as benzophenone, N,N'-tetramethyl-4,4'-diaminobenzophenone (Michler's ketone), N,N'-tetraethyl-4,4'-diaminobenzophenone, 4-methoxy-4'-dimethylaminobenzophenone, 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)-butanone-1,2-methyl-1-[4-(methylthio)phenyl]-2-morpholino-propanone-1, etc.; quinones such as 2-ethylanthraquinone, phenanthrenequinone, 2-tert-butylanthraquinone, octamethylanthraquinone, 1,2-benzanthraquinone, 2,3-benzanthraquinone, 2-phenylanthraquinone, 2,3-diphenylanthraquinone, 1-chloroanthraquinone, 2-methylanthraquinone, 1,4-naphthoquinone, 9,10-phenanthraquinone, 2-methyl-1,4-naphthoquinone, 2,3-dimethylanthraquinone, etc.; benzoin ether compounds such as benzoin, methylbenzoin, ethylbenzoin, etc.; benzil derivatives such as benzil dimethyl ketal, etc.; 2,4,5-triarylimidazole dimers such as 2-(o-chlorophenyl)-4,5-diphenylimidazole dimer, 2-(o-chlorophenyl)-4,5-di(methoxyphenyl)imidazole dimer, 2-(o-fluorophenyl)-4,5-diphenylimidazole dimer, 2-(o-methoxyphenyl)-4,5-diphenylimidazole dimer, 2-(p-methoxyphenyl)-4,5-diphenylimidazole dimer, etc.; acridine derivatives such as 9-phenylacridine, 1,7-bis(9,9'-acridinyl)heptane, etc.; N-phenylglycine, N-phenylglycine derivative, coumarin type compound, etc.

Substituents of the two aryl groups possessed by 2,4,5-triarylimidazole may be the same to provide a symmetric

compound or different from each other to provide an asymmetric compound.

Also, a thioxanthone type compound and a tertiary amine compound may be used in combination as in the combination of  
5 diethylthioxanthone and dimethylaminobenzoic acid.

Also, 2,4,5-triarylimidazole dimer is more preferably used in view of adhesiveness and sensitivity. These compounds may be used singly or in combination of two or more.

An amount of Component (A) to be formulated in the present  
10 invention is preferably 50 to 70 parts by weight, more preferably 55 to 65 parts by weight based on the total 100 parts by weight of Component (A) and Component (B). If the amount is less than 40 parts by weight, film-forming property tends to be lowered when it is used as a photosensitive element, while  
15 if it exceeds 80 parts by weight, photocuring tends to be insufficient.

An amount of Component (B) to be formulated in the present invention is preferably 30 to 50 parts by weight, more preferably 35 to 45 parts by weight based on the total 100 parts  
20 by weight of Component (A) and Component (B). If the amount is less than 20 parts by weight, photocuring tends to be insufficient, while if it exceeds 60 parts by weight, film-forming property tends to be lowered.

An amount of Component (C) to be formulated in the present  
25 invention is preferably 0.01 to 20 parts by weight, more preferably 0.05 to 10 parts by weight, particularly preferably 0.1 to 5 parts by weight based on the total 100 parts by weight of Component (A) and Component (B). If the amount is less than 0.01 part by weight, sensitivity tends to be insufficient, while  
30 if it exceeds 20 parts by weight, resolution tends to be worsened.

To the photosensitive resin composition of the present invention may be added, depending on necessity, a dye such as Malachite Green, etc.; a light coloring agent such as leuco  
35 Crystal Violet, etc.; a thermal coloration preventive agent; a plasticizer such as p-toluenesulfonic acid amide, etc., a

pigment, a filler, a defoaming agent, a flame retardant, a stabilizer, an adhesiveness-imparting agent, a leveling agent, a peeling promoting agent, an antioxidant, a perfume, an imaging agent, a heat cross-linking agent, etc., each in an amount of 0.01 to 20 parts by weight based on the total 100 parts by weight of Component (A) and Component (B). These compounds may be used singly or in combination of two or more.

The photosensitive resin composition of the present invention may be coated as a solution with a solid content of about 30 to 60% by weight by dissolving it in a solvent such as methyl alcohol, ethyl alcohol, acetone, methyl ethyl ketone, ethylene glycol monomethyl ether, ethylene glycol monoethyl ether, toluene, N-dimethylformamide, etc., or a mixed solvent of the above solvents, if necessary.

Also, a thickness of the photosensitive resin composition layer may vary depending on the use, and preferably 1 to 200  $\mu\text{m}$ , more preferably 1 to 100  $\mu\text{m}$ , particularly preferably 1 to 30  $\mu\text{m}$  with a thickness after drying. If the thickness is less than 1  $\mu\text{m}$ , formation of a film tends to be industrially difficult, while if it exceeds 200  $\mu\text{m}$ , photocuring property at the bottom portion of a resist tends to be worsened.

The photosensitive element of the present invention comprising two layers of the thus obtained photosensitive resin composition layer and a support film is stored by, for example, winding it around a core as such or further laminating a protective film on the other surface (the surface opposed to the surface existing the support film) of the photosensitive resin composition layer. Incidentally, at this time, it is preferred to wind the photosensitive element so that the support film is the outermost layer. A winding rate and a winding tension at the time of winding can be optionally determined. As the above protective film, there may be mentioned, for example, an inert polyolefin film such as polyethylene, polypropylene, etc., and the polyethylene film is preferred in view of peeling property from the photosensitive resin composition layer. Also, it is preferred to use a protective

film with a low fish eye to avoid occurrence of air voids. An edge surface separator is preferably provided at the edge surface of the above roll-shaped photosensitive element roll to protect the edge surface, and a moistureproof edge surface separator is preferably provided to prevent edge fusion. The photosensitive element roll is preferably packed by wrapping with a black sheet having a low permeability. In the present specification, the term "edge fusion" means a phenomenon in which the photosensitive resin composition layer is oozed out from the edge surface of the photosensitive element roll.

As the above core, a cylindrical shape core is preferred and the core may comprise, for example, plastics such as polyethylene resin, polypropylene resin, polystyrene resin, polyvinyl chloride resin, ABS resin (acrylonitrile-butadiene-styrene copolymer), etc., paper, and the like.

The photosensitive element roll of the present invention is a material, as shown in Fig. 1, in which a photosensitive element 2 is winding around a core 1. When the photosensitive element roll 3 is naturally dropped five times from the height of 10 cm to a collision surface 4 so that the axis direction of the core 1 becomes perpendicular to the collision surface 4, a total height of winding deviation at the edge surface of the photosensitive element roll 3 after the above operation is 1 mm or less.

The above dropping is preferably carried out continuously five times, more preferably continuously carried out five times in 1 minute. Also, the above dropping test is preferably carried out after storing the above photosensitive element roll in an insulating container at about 0 to 10°C for 8 to 12 hours.

A size of the above core may be mentioned, for example, a diameter of 5 to 10 cm and a length to the axis direction of 10 to 80 cm, and the like.

A width of the photosensitive element roll when the photosensitive element roll is winding around the core is not specifically limited, and preferably narrower than the length of the axis direction of the core, more preferably about 1 to

10 cm shorter than that of the core. A length of the photosensitive element roll to be wound around the core is not particularly limited, and preferably about 10 to 550 m.

5 The above collision surface 4 is preferably a material which is not broken even when the photosensitive element roll is dropped thereon, and may comprise, for example, a concrete surface, a metal surface, etc.

10 The total height of winding deviation at the edge surface of the photosensitive element roll after it was naturally dropped five times can be measured as mentioned below. First, as shown in Fig. 2, Fig. 3 and Fig. 4, an L-square 5 is put at the edge portion of the photosensitive element roll 3 so that an X piece of the L-square 5 becomes parallel to the plane passing through the axis direction of the core 1 and a Y piece of the same becomes perpendicular to the plane passing through the axis direction of the core 1. Next, a distance (a height d of winding deviation) of the winding deviation 6 occurred from the edge portion of the photosensitive element roll 3 to the top point is measured. In the present specification, as the height of the winding deviation, the maximum value of the winding deviation is employed and the value is made as a height of the winding deviation of the photosensitive element roll. Also, in the present specification, winding deviation means a difference of deviation at the edge surface of the photosensitive element roll before dropping and after dropping.

25 When a resist pattern is prepared by using the above photosensitive element, if a protective film is present, it can be prepared, for example, by removing the protective film, and bringing the photosensitive resin composition layer into  
30 contact with a substrate for forming a circuit by pressure under heating whereby the layer is laminated to the substrate. The lamination is preferably carried out under reduced pressure to obtain good adhesion and conformity. The surface to be laminated is generally a metal surface, but it is not  
35 particularly limited to these materials. A temperature of the photosensitive resin composition layer to be heated is



preferably 70 to 130°C, and a contact-bonding pressure is preferably 0.1 to 1 MPa (1 to 10 kgf/cm<sup>2</sup>), but it is not particularly limited to these ranges. Also, when the photosensitive resin composition layer is heated at 70 to 130°C, it is not necessary to pre-heat the substrate for forming a circuit. Moreover, in order to further improve lamination characteristics, a pre-heating treatment of the substrate for forming a circuit may be carried out.

Then, the photosensitive resin composition layer which has been thus laminated is imagewise irradiated by an active light through a negative or positive mask pattern which is so-called art work. At this time, when a polymer film existing on the photosensitive resin composition layer is transparent, active light may be irradiated as such, and when the polymer film is opaque, it is necessary to remove the film as a matter of course.

As a light source of the active light, there may be used a conventionally known light source which effectively irradiates ultraviolet rays such as carbon arc lamp, mercury vapor arc lamp, ultra-high pressure mercury lamp, high pressure mercury lamp, xenon lamp, etc. Also, a light source which irradiates visible rays, such as a photoflood lamp for photography, a sunlight lamp, etc. may be used.

Next, after exposure, when a support is present on the photosensitive resin composition layer, the support is removed, unexposed portion is removed and developed by wet development, dry development, etc., to prepare a resist pattern.

In the case of the wet development, development is carried out by the conventionally known method such as spray, dipping by rocking, brushing, scraping, etc. by using a developing solution corresponding to a photosensitive resin composition such as an aqueous alkaline solution, an aqueous developing solution, an organic solvent and the like.

As the developing solution, those which are safe, stable and easily operable such as an aqueous alkaline solution may be used.

As a base of the above aqueous alkaline solution, there may be used an alkali hydroxide such as a hydroxide of lithium, sodium or potassium, etc.; an alkali carbonate such as a carbonate or a bicarbonate of lithium, sodium, potassium or ammonium, etc.; an alkali metal phosphate such as potassium phosphate, sodium phosphate, etc.; and an alkali metal pyrophosphate such as sodium pyrophosphate, potassium pyrophosphate, etc.

As the aqueous alkaline solution to be used for development, preferred are a 0.1 to 5% by weight diluted sodium carbonate solution, a 0.1 to 5% by weight diluted potassium carbonate solution, a 0.1 to 5% by weight diluted sodium hydroxide solution, a 0.1 to 5% by weight diluted sodium tetraborate solution, and the like.

A pH of the aqueous alkaline solution to be used for development is preferably within the range of 9 to 11, and a temperature thereof can be controlled depending on the developability of the photosensitive resin composition layer.

To the aqueous alkaline solution may be added a surfactant, a defoaming agent, a small amount of an organic solvent to accelerate the development, etc.

The above aqueous developing solution comprises water or an aqueous alkaline solution, and at least one of an organic solvent. Here, as the alkali substance, in addition to the above substances, there may be mentioned, for example, borax, sodium metasilicate, tetramethylammonium hydroxide, ethanolamine, ethylenediamine, diethylenetriamine, 2-amino-2-hydroxymethyl-1,3-propanediol, 1,3-diaminopropanol-2, morpholine, etc.

A pH of the developing solution is preferably as low as possible within the range during which development of the resist can be sufficiently carried out, it is preferably a pH of 8 to 12, more preferably a pH of 9 to 10.

As the above organic solvent, there may be mentioned, for example, triacetonealcohol, acetone, ethyl acetate, alkoxy-ethanol having an alkoxy group with 1 to 4 carbon atoms, ethyl

alcohol, isopropyl alcohol, butyl alcohol, diethylene glycol monomethyl ether, diethylene glycol monoethyl ether, diethylene glycol monobutyl ether, etc. These solvents may be used singly or in combination of two or more.

5 A concentration of the organic solvent is generally preferably 2 to 90% by weight and a temperature thereof may be adjusted depending on the developability.

To the aqueous developing solution may be added a small amount of a surfactant, a defoaming agent, etc.

10 As an organic solvent type developing agent which can be used singly, there may be mentioned, for example, 1,1,1-trichloroethane, N-methylpyrrolidone, N,N-dimethylformamide, cyclohexanone, methyl isobutyl ketone,  $\gamma$ -butyrolactone, etc. Water is preferably added to the organic solvent in the range  
15 of 1 to 20% by weight to prevent inflammation. Also, if necessary, two or more developing systems may be used in combination.

In the developing system, there are a dipping system, a bottle system, a spray system, brushing, scraping, etc., and  
20 a high pressure spray system is most suitable for improving resolution.

As a post-developing treatment, the resist pattern may be further cured by heating at about 60 to 250°C or subjecting to exposure with 0.2 to 10 mJ/cm<sup>2</sup>, if necessary, and used.

25 The resist pattern of the present invention has further four characteristic features.

The first characteristic feature of the resist pattern according to the present invention resides in that unevenness on the side surface of the resist pattern is 0 to 3.0  $\mu$ m.

30 The second characteristic feature of the resist pattern according to the present invention resides in that a number of unevenness larger than 3.0  $\mu$ m on the center line of the side surface of the resist pattern is 0 to 5/4 mm.

The third characteristic feature of the resist pattern  
35 according to the present invention resides in that a mathematical average roughness ( $R_a$ ) on the side surface of the resist

pattern is 0 to 2.0  $\mu\text{m}$ .

The fourth characteristic feature of the resist pattern according to the present invention resides in that a maximum height ( $R_y$ ) on the side surface of the resist pattern is 0 to 3.0  $\mu\text{m}$ .

Here, the side surface of the resist pattern according to the present invention means, as shown in Fig. 5, a surface of a resist pattern in the direction perpendicular to the substrate 15 (a thickness direction of a photosensitive resin composition layer in a photosensitive element) in the resist pattern 7 obtained by imagewisely exposing a layer of the photosensitive resin composition layer laminated on the substrate from upper portion of the substrate to active light and then subjecting to development.

Also, unevenness on the side surface of the resist pattern according to the present invention means, as shown in Fig. 5, linear grooves 9 existing on the side surface 8 of the resist pattern perpendicular to the substrate 15 (a thickness direction of a photosensitive resin composition layer in a photosensitive element).

The unevenness on the side surface of the resist pattern in the first characteristic feature of the resist pattern according to the present invention is required to be 0 to 3.0  $\mu\text{m}$ , preferably 0 to 2.8  $\mu\text{m}$ , more preferably 0 to 2.5  $\mu\text{m}$ , further preferably 0 to 2.3  $\mu\text{m}$ , particularly preferably 0 to 2.0  $\mu\text{m}$ , extremely preferably 0 to 1.8  $\mu\text{m}$ , and most extremely preferably 0 to 1.5  $\mu\text{m}$ . If the value exceeds 3.0  $\mu\text{m}$ , side wall flatness, electric resistance and line appearance of the resulting wiring pattern tend to be poor.

The number of unevenness larger than 3.0  $\mu\text{m}$  on the center line of the side surface of the resist pattern in the second characteristic feature of the resist pattern according to the present invention is required to be 0 to 5/4 mm, preferably 0 to 4/4 mm, more preferably 0 to 3/4 mm, further preferably 0 to 2/4 mm, particularly preferably 0 to 1/4 mm, and extremely preferably 0/4 mm. If the value exceeds 5/4 mm, side wall

flatness, electric resistance and line appearance of the resulting wiring pattern tend to be poor.

The mathematical average roughness ( $R_a$ ) on the side surface of the resist pattern in the third characteristic feature of the resist pattern according to the present invention is required to be 0 to 2.0  $\mu\text{m}$ , preferably 0 to 1.8  $\mu\text{m}$ , more preferably 0 to 1.5  $\mu\text{m}$ , further preferably 0 to 1.3  $\mu\text{m}$ , particularly preferably 0 to 1.0  $\mu\text{m}$ , extremely preferably 0 to 0.8  $\mu\text{m}$ , and most extremely preferably 0 to 0.5  $\mu\text{m}$ . If the value exceeds 2.0  $\mu\text{m}$ , side wall flatness, electric resistance and line appearance of the resulting wiring pattern tend to be poor.

The maximum height ( $R_y$ ) on the side surface of the resist pattern in the fourth characteristic feature of the resist pattern according to the present invention is required to be 0 to 3.0  $\mu\text{m}$ , preferably 0 to 2.8  $\mu\text{m}$ , more preferably 0 to 2.5  $\mu\text{m}$ , further preferably 0 to 2.3  $\mu\text{m}$ , particularly preferably 0 to 2.0  $\mu\text{m}$ , extremely preferably 0 to 1.8  $\mu\text{m}$ , and most extremely preferably 0 to 1.5  $\mu\text{m}$ . If the value exceeds 3.0  $\mu\text{m}$ , side wall flatness, electric resistance and line appearance of the resulting wiring pattern tend to be poor.

The width of the resist pattern according to the present invention is not specifically limited, and preferably 1  $\mu\text{m}$  or more, more preferably 3  $\mu\text{m}$  or more, further preferably 5  $\mu\text{m}$  or more, particularly preferably 5 to 1000  $\mu\text{m}$ , more particularly preferably 6 to 1000  $\mu\text{m}$ , extremely preferably 7 to 1000  $\mu\text{m}$ , more extremely preferably 8 to 1000  $\mu\text{m}$ , further extremely preferably 9 to 900  $\mu\text{m}$ , and most extremely preferably 10 to 800  $\mu\text{m}$ .

The height of the resist pattern according to the present invention is not specifically limited, and preferably 1 to 150  $\mu\text{m}$ , more preferably 1 to 110  $\mu\text{m}$ , further preferably 2 to 100  $\mu\text{m}$ , particularly preferably 3 to 90  $\mu\text{m}$ , extremely preferably 4 to 80  $\mu\text{m}$ , and most extremely preferably 5 to 75  $\mu\text{m}$ .

The unevenness on the side surface of the resist pattern according to the present invention can be measured, for example, as mentioned below. First, a photosensitive resin composition layer is laminated on a substrate, and then, the material is

exposed (30 to 200 mJ/cm<sup>2</sup> or so: it is optionally selected so that a rectangular-shaped resist pattern can be obtained) and developed (0.1 to 5% by weight dilute sodium carbonate solution, etc., 20 to 40°C or so: it is optionally selected so that a rectangular-shaped resist pattern can be obtained) by using a linear negative pattern (having windows through which active light with the size of 100 μm x 1 cm is passed) to form a linear and rectangular-shaped resist pattern (width: 100 μm, length: 1 cm, height: a thickness of the photosensitive resin composition layer).

Here, as shown in Fig. 6, a surface of the resist pattern perpendicular to the substrate and parallel to the lengthwise direction of the resist pattern 7 is made a side surface 8 of the resist pattern, and a lateral width of the side surface 8 of the resist pattern is made a height of the resist pattern. Also, the lateral width of the surface of the resist pattern parallel to the substrate and perpendicular to the side surface of the resist pattern is made a width of the resist pattern. Then, on the side surface 8 of the resist pattern, two lines perpendicular to the substrate are optionally drawn and their respective center points are each called as a center point S 10 and a center point T 11. These center points S 10 and T 11 are linked with a line and the line is called to as a center line 12 (the center points S 10 and T 11 are placed so that the length of the center line 12 becomes 4 mm) of the side surface 8 of the resist pattern. Here, unevenness on the side surface of the resist pattern is measured within the range of the center line 12 (length: 4 mm) of the side surface 8 of the resist pattern.

The above-mentioned unevenness on the center line of the side surface of the resist pattern means, as shown in Figs. 7 and 8, a line perpendicular to a tangent line of the two convex portions adjacent to each other and parallel to the substrate, and shows a distance between a deepest point 13 of the concave portion located between the two convex portions adjacent to each other and a point of intersection 14 which is a point of

intersection of a line passing through the deepest point 13 of the concave portions located between the two convex portions adjacent to each other and the above tangent line. Incidentally, Fig. 7 is a sectional view in which it is cut with a surface passing through the center line on the side surface of the resist pattern and parallel to the substrate, and Fig. 8 is an enlarged sectional view of the uneven portion of Fig. 7.

The unevenness on the center line on the side surface of the above-mentioned resist pattern can be measured by, for example, an optical microscope, a scanning type electron microscope (SEM), a contact type surface roughness measurement apparatus, a non-contact type three dimensional surface roughness measurement apparatus, a Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan, etc.), a Color Lazer 3D Profile Microscope (VK-8500, trade name, manufactured by Keyence, Japan, etc.) and the like.

The unevenness on the side surface of the resist pattern can be easily measured from the perpendicular direction by using an apparatus capable of measuring the unevenness to the depth direction without contacting the material to be measured such as the above-mentioned Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan, etc.), the Color Lazer 3D Profile Microscope (VK-8500, trade name, manufactured by Keyence, Japan, etc.) and the like.

When the unevenness on the side surface of the resist pattern is measured by using the above-mentioned optical microscope, the scanning type electron microscope (SEM), etc., the unevenness can be easily measured by observing, from the upper side of the substrate, the sectional surface of the resist pattern along with the center line obtained by cutting the side surface 8 of the resist pattern in a direction passing through the center line 12 which is parallel to the substrate and perpendicular to the side surface of the resist pattern. Also, the unevenness can be observed from diagonally upper the resist pattern without cutting the same.

The mathematical average roughness ( $R_a$ ) and the maximum

height ( $R_y$ ) on the side surface of the resist pattern according to the present invention can be also measured, for example, by the same manner as that of the method for measuring the unevenness on the side surface of the resist pattern as mentioned above. Incidentally, the mathematical average roughness ( $R_a$ ) and the maximum height ( $R_y$ ) in the present invention are measured according to JIS B 0601 and values at which a cut-off value  $\lambda_c=0.8$  mm and an evaluation length  $l_n=4$  mm.

The mathematical average roughness ( $R_a$ ) and the maximum height ( $R_y$ ) of the side surface of the resist pattern as mentioned above can be measured, for example, by a contact type surface roughness measuring apparatus, a Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan, etc.), a Color Laser 3D Profile Microscope (VK-8500, trade name, manufactured by Keyence, Japan, etc.) and the like. It is preferred to use a Profile Measurement Microscope, a Color Laser 3D Profile Microscope, etc., which are capable of effecting non-contact measurement.

For effecting etching of a metal surface to be carried out after development, there may be used a cupric chloride solution, a ferric chloride solution, an alkali etching solution, a hydrogen peroxide type etching solution, etc. It is desired to use a ferric chloride solution in the point of having a good etch factor.

When a printed wiring board is to be produced by using the photosensitive element according to the present invention, the surface of a substrate for forming a circuit is treated by the conventionally known method such as etching, plating, etc., by using the developed resist pattern as a mask.

As the above plating method, there may be mentioned, for example, copper plating such as copper sulfate plating, copper pyrophosphate plating, etc.; solder plating such as high sold solder plating, etc.; nickel plating such as Watt bath (nickel sulfate-nickel chloride) plating, nickel sulfamate plating, etc.; gold plating such as hard gold plating, soft gold plating,



etc.

As mentioned above, a wiring pattern can be obtained by subjecting the substrate for forming a circuit on which a resist pattern has been formed to etching or plating.

5 On the other hand, the wiring pattern of the present invention has further four characteristics as mentioned below.

The first characteristic feature of the wiring pattern according to the present invention resides in that unevenness on the side surface of the resist pattern is 0 to 3.0  $\mu\text{m}$ .

10 The second characteristic feature of the wiring pattern according to the present invention resides in that a number of unevenness larger than 3.0  $\mu\text{m}$  on the center line of the side surface of the resist pattern is 0 to 5/4 mm.

The third characteristic feature of the wiring pattern  
15 according to the present invention resides in that a mathematical average roughness ( $R_a$ ) on the side surface of the resist pattern is 0 to 2.0  $\mu\text{m}$ .

The fourth characteristic feature of the wiring pattern according to the present invention resides in that a maximum  
20 height ( $R_y$ ) on the side surface of the resist pattern is 0 to 3.0  $\mu\text{m}$ .

The wiring pattern of the present invention tends to be etched or plated along with the unevenness on the side surface of the resist pattern so that it is preferred that the unevenness  
25 on the side surface of the wiring pattern is small in view of line appearance and electric resistance.

The unevenness on the side surface of the wiring pattern in the first characteristic feature of the wiring pattern according to the present invention is required to be 0 to 3.0  
30  $\mu\text{m}$ , preferably 0 to 2.8  $\mu\text{m}$ , more preferably 0 to 2.5  $\mu\text{m}$ , further preferably 0 to 2.3  $\mu\text{m}$ , particularly preferably 0 to 2.0  $\mu\text{m}$ , extremely preferably 0 to 1.8  $\mu\text{m}$ , and most extremely preferably 0 to 1.5  $\mu\text{m}$ . If the value exceeds 3.0  $\mu\text{m}$ , side wall flatness, electric resistance and line appearance of the resulting wiring  
35 pattern tend to be poor.

The number of unevenness larger than 3.0  $\mu\text{m}$  on the center

line of the side surface of the wiring pattern in the second characteristic feature of the wiring pattern according to the present invention is required to be 0 to 5/4 mm, preferably 0 to 4/4 mm, more preferably 0 to 3/4 mm, further preferably 0 to 2/4 mm, particularly preferably 0 to 1/4 mm, and extremely preferably 0/4 mm. If the value exceeds 5/4 mm, side wall flatness, electric resistance and line appearance of the resulting wiring pattern tend to be poor.

The mathematical average roughness ( $R_a$ ) on the side surface of the wiring pattern in the third characteristic feature of the wiring pattern according to the present invention is required to be 0 to 2.0  $\mu\text{m}$ , preferably 0 to 1.8  $\mu\text{m}$ , more preferably 0 to 1.5  $\mu\text{m}$ , further preferably 0 to 1.3  $\mu\text{m}$ , particularly preferably 0 to 1.0  $\mu\text{m}$ , extremely preferably 0 to 0.8  $\mu\text{m}$ , and most extremely preferably 0 to 0.5  $\mu\text{m}$ . If the value exceeds 2.0  $\mu\text{m}$ , side wall flatness, electric resistance and line appearance of the resulting wiring pattern tend to be poor.

The maximum height ( $R_y$ ) on the side surface of the wiring pattern in the fourth characteristic feature of the wiring pattern according to the present invention is required to be 0 to 3.0  $\mu\text{m}$ , preferably 0 to 2.8  $\mu\text{m}$ , more preferably 0 to 2.5  $\mu\text{m}$ , further preferably 0 to 2.3  $\mu\text{m}$ , particularly preferably 0 to 2.0  $\mu\text{m}$ , extremely preferably 0 to 1.8  $\mu\text{m}$ , and most extremely preferably 0 to 1.5  $\mu\text{m}$ . If the value exceeds 3.0  $\mu\text{m}$ , side wall flatness, electric resistance and line appearance of the resulting wiring pattern tend to be poor.

The width of the wiring pattern according to the present invention is not specifically limited, and preferably 1  $\mu\text{m}$  or more, more preferably 3  $\mu\text{m}$  or more, further preferably 5  $\mu\text{m}$  or more, particularly preferably 5 to 1000  $\mu\text{m}$ , more particularly preferably 6 to 1000  $\mu\text{m}$ , extremely preferably 7 to 1000  $\mu\text{m}$ , more extremely preferably 8 to 1000  $\mu\text{m}$ , further extremely preferably 9 to 900  $\mu\text{m}$ , and most extremely preferably 10 to 800  $\mu\text{m}$ .

The height of the wiring pattern according to the present invention is not specifically limited, and preferably 0.01 to 200  $\mu\text{m}$ , more preferably 0.02 to 190  $\mu\text{m}$ , further preferably 0.03

to 180  $\mu\text{m}$ , particularly preferably 0.05 to 150  $\mu\text{m}$ , further particularly preferably 0.08 to 130  $\mu\text{m}$ , extremely preferably 0.10 to 100  $\mu\text{m}$ , further extremely preferably 1.00 to 100  $\mu\text{m}$ , and most extremely preferably 5.00 to 50  $\mu\text{m}$ .

5       The unevenness on the side surface of the wiring pattern according to the present invention can be measured, for example, as mentioned below. First, a resist pattern is formed on a substrate for forming a circuit, and then, the resulting material is subjected to etching (an aqueous ferric chloride solution, an aqueous cupric chloride solution, etc., 40 to 60°C or so) to prepare a linear wiring pattern (width: 100  $\mu\text{m}$ , length: 1 cm, height: a thickness of the metal layer of the substrate for forming a circuit). Here, in the same manner as in the side surface of the resist pattern, a surface of the wiring pattern perpendicular to the substrate and parallel to the lengthwise direction of the wiring pattern is made a side surface of the wiring pattern, and a lateral width of the side surface of the wiring pattern is made a height of the wiring pattern. Also, the lateral width of the surface of the wiring pattern parallel to the substrate and perpendicular to the side surface of the wiring pattern is made a width of the wiring pattern. Then, on the side surface of the wiring pattern, two lines perpendicular to the substrate are optionally drawn and their respective center points are each called as a center point M and a center point N. These center points M and N are linked with a line and the line is called to as a center line (the center points M and N are placed so that the length of the center line becomes 4 mm) of the side surface of the wiring pattern. Here, unevenness on the side surface of the wiring pattern is measured within the range of the center line (length: 4 mm) of the side surface of the wiring pattern.

      The above-mentioned unevenness on the center line on the side surface of the wiring pattern means a line perpendicular to a tangent line of the two convex portions adjacent to each other and parallel to the substrate as in the unevenness on the center line on the side surface of the resist pattern, and shows

a distance between a deepest point of the concave portion located between the two convex portions adjacent to each other and a point of intersection which is a point of intersection of a line passing through the deepest point of the concave portions located between the two convex portions adjacent to each other and the above tangent line.

The unevenness on the center line on the side surface of the above-mentioned wiring pattern can be measured by, for example, an optical microscope, a scanning type electron microscope (SEM), a contact type surface roughness measurement apparatus, a non-contact type three dimensional surface roughness measurement apparatus, a Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan, etc.), a Color Lazer 3D Profile Microscope (VK-8500, trade name, manufactured by Keyence, Japan, etc.) and the like.

The unevenness on the side surface of the wiring pattern can be easily measured from the perpendicular direction by using an apparatus capable of measuring the unevenness to the depth direction without contacting the material to be measured such as the above-mentioned Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan, etc.), the Color Lazer 3D Profile Microscope (VK-8500, trade name, manufactured by Keyence, Japan, etc.) and the like.

When the unevenness on the side surface of the wiring pattern is measured by using the above-mentioned optical microscope, the scanning type electron microscope (SEM), etc., the unevenness can be easily measured by observing, from the upper side of the substrate, the sectional surface of the wiring pattern along with the center line obtained by cutting the side surface of the wiring pattern in a direction passing through the center line which is parallel to the substrate and perpendicular to the side surface of the wiring pattern. Also, the unevenness can be observed from diagonally upper the wiring pattern without cutting the same.

The mathematical average roughness ( $R_a$ ) and the maximum height ( $R_y$ ) on the side surface of the wiring pattern according

to the present invention can be also measured, for example, by the same manner as that of the method for measuring the unevenness on the side surface of the wiring pattern as mentioned above. Incidentally, the mathematical average roughness ( $R_a$ ) and the maximum height ( $R_y$ ) in the present invention are measured according to JIS B 0601 and values at which a cut-off value  $\lambda_c=0.8$  mm and an evaluation length  $l_n=4$  mm.

The mathematical average roughness ( $R_a$ ) and the maximum height ( $R_y$ ) of the side surface of the wiring pattern as mentioned above can be measured, for example, by a contact type surface roughness measuring apparatus, a Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan, etc.), a Color Laser 3D Profile Microscope (VK-8500, trade name, manufactured by Keyence, Japan, etc.) and the like. It is preferred to use a Profile Measurement Microscope, a Color Laser 3D Profile Microscope, etc., which are capable of effecting non-contact measurement.

Then, the resist pattern can be peeled off, for example, by an aqueous alkali solution stronger than the aqueous alkali solution used in the development.

As such an aqueous strong alkali solution, there may be used an aqueous 1 to 10% by weight sodium hydroxide solution, an aqueous 1 to 10% by weight potassium hydroxide solution and the like.

As the peeling method, there may be mentioned, for example, a dipping system, a spraying system, etc., and the dipping system and the spraying system may be used singly or in combination. Also, the printed wiring board to which a resist pattern has been formed may be a multi-layer printed wiring board.

#### Examples

Next, the present invention will be explained in more detail by referring to Examples.

Examples 1 and 2, and Comparative examples 1 to 3

Component (A) was synthesized by using the components shown in Table 1 to prepare a solution, and Component (B), Component (C), other components and solvents were mixed with the solution to prepare a solution of a photosensitive resin composition.

Table 1

	Material	Formulation amount
Component (A)	40% by weight solution of methacrylic acid/methyl methacrylate/styrene copolymer (weight ratio: 25/50/25, weight average molecular weight: 70,000, acid value: 163 mg KOH/g) in toluene/methyl cellosolve (weight ratio: 4/6)	150 g (solid component: 60 g)
Component (B)	2,2-Bis(4-(methacryloxy-pentaethoxy)phenyl)propane	30.0 g
	$\gamma$ -Chloro- $\beta$ -hydroxypropyl- $\beta'$ -methacryloxyethyl-o-phthalate	10.0 g
Component (C)	2-(o-Chlorophenyl)-4,5-diphenylimidazole dimer	3.0 g
	N,N'-Tetraethyl-4,4'-diaminobenzophenone	0.15 g
Other Components	Leuco Crystal Violet	0.5 g
	Marachite Green	0.05 g
	p-Toluenesulfonic amide	4.0 g
Solvents	Acetone	10.0 g
	Toluene	10.0 g
	Methanol	3.0 g
	N,N-Dimethylformamide	3.0 g

The resulting solution of the photosensitive resin composition was uniformly coated on a support film (A2100-16 and A4100-25 (biaxially oriented polyethylene terephthalate each having a resin layer containing fine particles on one surface thereof), available from Toyo Boseki K.K., Japan; G2-16, G2-19 and V-20 (polyethylene terephthalate each having no resin layer containing fine particles), available from Teijin Limited,

Japan) shown in Table 2 and dried in an oven with internal air circulation at 100°C for 10 minutes to obtain respective photosensitive elements. Each film thickness of the photosensitive resin composition layer after drying was 20  $\mu$ m.

5 Hazes of the support films shown in Table 2 were measured according to JIS K 7105 by using a haze meter (TC-H3DP, trade name, manufactured by Tokyo Denshoku K.K., Japan).

Also, 5 sheets of test pieces with a width of 20 mm and a length of 150 mm were cut out along with the longitudinal  
10 direction and the lateral direction, respectively, and then, gage points were marked at the center portion of the respective test pieces with a distance of 100 mm. The test pieces were vertically hanged in a thermostat with internal air circulation maintained at  $105 \pm 3^\circ\text{C}$ ,  $150 \pm 3^\circ\text{C}$  and  $200 \pm 3^\circ\text{C}$  for 30 minutes,  
15 taken out and allowed to stand at room temperature for 30 minutes, and the distance between the gage points was measured. The heat shrinkage ratio was calculated from the above-mentioned scheme (2) and an average of the respective samples was calculated.

Next, a copper surface of a copper-clad laminated board  
20 (MCL-E-61, trade name, available from Hitachi Chemical Co., Ltd., Japan) which comprises a glass-epoxy material on which copper foils (each a thickness of 35  $\mu$ m) had been laminated on the both surfaces thereof was polished by using a polishing machine (manufactured by Sankei K.K., Japan) having a brush  
25 corresponding to #600, washed with water and dried with air stream. The resulting copper-clad laminated board was heated to 80°C, and the above-mentioned photosensitive resin composition layer was laminated on the copper surface at 120°C and 0.4 MPa (4 kgf/cm<sup>2</sup>).

30 Thereafter, exposure was carried out by using an exposure machine (model: HMW-201B, trade name, manufactured by Orc Seisakusho Co., Japan) having a 3KW ultra high pressure mercury lamp in such an energy dose that the number of remaining step grades after development became 8.0, using a photo tool having  
35 a Stofer 21 grade step tablet as a negative mask and a photo tool having a wiring pattern with a line/space of 30/400 to

250/400 (resolution, unit:  $\mu\text{m}$ ) as a negative mask for evaluating adhesive property. Then, the support film was removed, and development was carried out by spraying a 1.0% by weight aqueous sodium carbonate solution at 30°C. Here, the adhesive property was evaluated with the minimum value of the line width among the fine lines adhered to the substrate after the development. The smaller numerical value obtained by the adhesive property test means better results.

Thereafter, by using a comb-shaped pattern with 5  $\mu\text{m}$ , a resist pattern was prepared by the same manner as that of the adhesion property test, and resolution ( $\mu\text{m}$ ) was evaluated from the remaining resist pattern. The smaller numerical value obtained by the resolution test means better results.

Next, exposure was carried out with the above-mentioned energy dose and a line width/space width of 50  $\mu\text{m}$ /50  $\mu\text{m}$  followed by development, and the shape of the resulting resist pattern was observed by a scanning type electron microscope to evaluate the nick property on the side surface of the resist pattern. The nick property on the side surface of the resist pattern means the state in which the shape of the resist pattern is not plain and an unfavorable side surface is present on the side of the resist pattern. The unevenness due to the nick on the side surface of the resist pattern is preferably shallow.

Deep: The case where unevenness of the side surface's nick exceeds 2  $\mu\text{m}$ .

Shallow: The case where unevenness of the side surface's nick is not more than 2  $\mu\text{m}$ .

The results are shown in Table 2.

Also, the contact angles of the X surface (a surface to which the photosensitive resin composition is coated and dried) and the Y surface (a surface opposite to the surface to which the photosensitive resin composition is coated and dried) of the support films shown in Table 2 were measured according to JIS R 3257 and using a contact angle meter CA-A (trade name, available from Kyowa Kaimen Kagaku K.K., Japan, QI optical mirror system).



Table 2

Support film	Example 1	Example 2	Comparative example 1	Comparative example 2	Comparative example 3
Thickness of support film ( $\mu\text{m}$ )	A2100-16	A4100-25	G2-16	G2-19	V-20
	16	25	16	19	20
Haze (%)	0.2	0.8	2.2	2.5	5.5
Thermal shrinkage ratio (%)	105°C	0.46	0.49	0.50	0.53
	150°C	1.35	1.51	2.00	2.33
	200°C	4.09	4.84	7.03	7.91
	105°C	0.00	0.00	0.00	0.01
	150°C	0.01	0.18	0.92	0.95
	200°C	0.85	0.99	5.55	6.03
(Contact angle of X surface)/(Contact angle of Y surface)	>1.1	>1.1	$\leq 1.1$	$\leq 1.1$	$\leq 1.1$
Resolution ( $\mu\text{m}$ )	15	20	20	20	30
Adhesive property ( $\mu\text{m}$ )	15	15	20	20	25
Side wall flatness of a resist pattern	Shallow	Shallow	Deep	Deep	Deep

### Example 3

The photosensitive element prepared in Example 1 was laminated on a copper-clad laminated board (MCL-E-61, trade name, available from Hitachi Chemical Co., Ltd.) which is a glass epoxy material on which copper foils (a thickness: 35  $\mu\text{m}$ ) had been laminated on the both surfaces thereof in the same manner as in Example 1. Next, exposure was carried out in the same manner as in Example 1 in such an energy dose that the number of remaining step after development became 8.0 by using a linear negative pattern (having an window which transmits active light with a size of 100  $\mu\text{m}$  x 1 cm) as a negative material.

When the unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was measured by a Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan), the deepest unevenness was 0.9  $\mu\text{m}$ . Also, when a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface of the resulting resist pattern were measured (a cut-off value:  $\lambda_c=0.8$  mm, an evaluation length  $l_n=4$  mm) by the Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan), the results of  $R_a=0.3$   $\mu\text{m}$  and  $R_y=1.0$   $\mu\text{m}$  were obtained.

### Example 4

A resist pattern was prepared in the same manner as in Example 3 except for using the photosensitive element prepared in Example 2 in place of that prepared in Example 1.

The deepest unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was 1.0  $\mu\text{m}$ . Also, a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface of the resulting resist pattern were  $R_a=0.4$   $\mu\text{m}$  and  $R_y=1.0$   $\mu\text{m}$ , respectively.

### Comparative example 4

A resist pattern was prepared in the same manner as in Example 3 except for using the photosensitive element prepared in Comparative example 1 in place of that prepared in Example

1.

The deepest unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was 5.0  $\mu\text{m}$ , and the number of the unevenness larger than 3.0  $\mu\text{m}$  was 8.

5 Also, a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface of the resulting resist pattern were  $R_a=2.3 \mu\text{m}$  and  $R_y=5.0 \mu\text{m}$ , respectively.

Comparative example 5

10 A resist pattern was prepared in the same manner as in Example 3 except for using the photosensitive element prepared in Comparative example 2 in place of that prepared in Example 1.

15 The deepest unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was 5.1  $\mu\text{m}$ , and the number of the unevenness larger than 3.0  $\mu\text{m}$  was 9. Also, a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface of the resulting resist pattern were  $R_a=2.2 \mu\text{m}$  and  $R_y=5.1 \mu\text{m}$ , respectively.

20 Comparative example 6

A resist pattern was prepared in the same manner as in Example 3 except for using the photosensitive element prepared in Comparative example 3 in place of that prepared in Example 1.

25 The deepest unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was 5.5  $\mu\text{m}$ , and the number of the unevenness larger than 3.0  $\mu\text{m}$  was 7. Also, a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface of the resulting resist pattern were  $R_a=2.3 \mu\text{m}$  and  $R_y=5.5 \mu\text{m}$ , respectively.

Example 5

35 The photosensitive element prepared in Example 1 was laminated on a copper-clad laminated board (MCL-E-61, trade name, available from Hitachi Chemical Co., Ltd.) which is a

glass epoxy material in which copper foils (a thickness: 35  $\mu\text{m}$ ) had been laminated on the both surfaces thereof in the same manner as in Example 1. Then, exposure of the resulting material was carried out in the same manner as in Example 1 in such a manner that a linear wiring pattern (a width: 100  $\mu\text{m}$ , a length: 1 cm, a height: a metal layer thickness of the substrate for forming a circuit) can be obtained with an energy dose that the number of remaining step after development became 8.0, followed by development and an etching treatment with a ferric chloride solution at 50°C.

When the unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was measured by a Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan), the deepest unevenness was 0.9  $\mu\text{m}$ . Also, when a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface of the resulting resist pattern were measured (a cut-off value:  $\lambda_c=0.8$  mm, an evaluation length  $l_n=4$  mm) by the Profile Measurement Microscope (VF-7500, trade name, manufactured by Keyence, Japan), the results of  $R_a=0.3$   $\mu\text{m}$  and  $R_y=0.9$   $\mu\text{m}$  were obtained.

The resulting wiring pattern had good appearance and electric resistant characteristics thereof were also good.  
Example 6

A resist pattern was prepared in the same manner as in Example 5 except for using the photosensitive element prepared in Example 2 in place of that prepared in Example 1.

The deepest unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was 1.0  $\mu\text{m}$ . Also, a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface of the resulting resist pattern were  $R_a=0.4$   $\mu\text{m}$  and  $R_y=1.0$   $\mu\text{m}$ , respectively.

The resulting wiring pattern had good appearance and electric resistant characteristics thereof were also good.  
Comparative example 7

A resist pattern was prepared in the same manner as in Example 5 except for using the photosensitive element prepared in Comparative example 1 in place of that prepared in Example 1.

5       The deepest unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was 5.0  $\mu\text{m}$ , and the number of the unevenness larger than 3.0  $\mu\text{m}$  was 8. Also, a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface  
10 of the resulting resist pattern were  $R_a=2.3 \mu\text{m}$  and  $R_y=5.0 \mu\text{m}$ , respectively.

The resulting wiring pattern was inferior in appearance to those obtained in Examples 5 and 6, and electric resistant characteristics thereof were also poor.

15 Comparative example 8

A resist pattern was prepared in the same manner as in Example 5 except for using the photosensitive element prepared in Comparative example 2 in place of that prepared in Example 1.

20       The deepest unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was 5.1  $\mu\text{m}$ , and the number of the unevenness larger than 3.0  $\mu\text{m}$  was 9. Also, a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface  
25 of the resulting resist pattern were  $R_a=2.2 \mu\text{m}$  and  $R_y=5.1 \mu\text{m}$ , respectively.

The resulting wiring pattern was inferior in appearance to those obtained in Examples 5 and 6, and electric resistant characteristics thereof were also poor.

30 Comparative example 9

A resist pattern was prepared in the same manner as in Example 5 except for using the photosensitive element prepared in Comparative example 3 in place of that prepared in Example 1.

35       The deepest unevenness on the center line (a length: 4 mm) of the side surface of the resulting resist pattern was 5.5

$\mu\text{m}$ , and the number of the unevenness larger than  $3.0 \mu\text{m}$  was 7. Also, a mathematical average roughness ( $R_a$ ) and a maximum height ( $R_y$ ) on the center line (a length: 4 mm) of the side surface of the resulting resist pattern were  $R_a=2.3 \mu\text{m}$  and  $R_y=5.5 \mu\text{m}$ , respectively.

The resulting wiring pattern was inferior in appearance to those obtained in Examples 5 and 6, and electric resistant characteristics thereof were also poor.

#### Example 7

A polyethylene film was laminated as a protective film on the photosensitive element obtained in Example 1, on the surface of a photosensitive resin composition layer, opposite to a support film. Next, the photosensitive element (a width: 55 cm, a length: 300 m) was wound around a core (a diameter: 8 cm, a length to the axis direction: 60 cm) so that the surface having the support film became outside to obtain a wound photosensitive element roll. The resulting photosensitive element roll was stored in an insulating container at  $0^\circ\text{C}$  for 10 hours.

After storage in the insulating container, the photosensitive element roll was dropped five times from the height of 10 cm to a concrete surface (a collision surface) so that the axis direction of the core became perpendicular to the collision surface. Incidentally, dropping was successively carried out five times within one minute.

A total height of winding deviation at the edge surface of the photosensitive element roll after five times dropping was 0.5 mm.

#### Example 8

The same experiment as in Example 7 was carried out except for using the photosensitive element prepared in Example 2 in place of that prepared in Example 1.

A total height of winding deviation at the edge surface of the photosensitive element roll after five times dropping was 0.6 mm.

Comparative example 10

The same experiment as in Example 7 was carried out except for using the photosensitive element prepared in Comparative example 1 in place of that prepared in Example 1.

5 A total height of winding deviation at the edge surface of the photosensitive element roll after five times dropping was 5.0 mm.

Comparative example 11

10 The same experiment as in Example 7 was carried out except for using the photosensitive element prepared in Comparative example 2 in place of that prepared in Example 1.

A total height of winding deviation at the edge surface of the photosensitive element roll after five times dropping was 4.0 mm.

Comparative example 12

15 The same experiment as in Example 7 was carried out except for using the photosensitive element prepared in Comparative example 3 in place of that prepared in Example 1.

20 A total height of winding deviation at the edge surface of the photosensitive element roll after five times dropping was 6.0 mm.

#### Industrial Applicability

25 The photosensitive element of the present invention is excellent in side wall flatness of a resist pattern, flatness on an upper surface of the same, resolution, adhesiveness, alkaline developability, productivity and operatability, and having less number of mouse bites.

30 The photosensitive element of the present invention is excellent in side wall flatness of a resist pattern, in addition to the above effects.

The photosensitive element of the present invention is excellent in resolution, in addition to the above effects.

35 The photosensitive element of the present invention is excellent in dimensional stability at the time of lamination in addition to the above effects.

The photosensitive element of the present invention is

excellent in film strength after hardening the resist in addition to the above effects.

The photosensitive element of the present invention is excellent in peeling property in addition to the above effects.

5 The photosensitive element of the present invention is excellent in cold flow property at storage in addition to the above effects.

10 The photosensitive element roll of the present invention is excellent in side wall flatness of a resist pattern, flatness on an upper surface of the same, resolution, adhesiveness, alkaline developability, winding deviation during shipping, productivity and operatability, and having less number of mouse bites.

15 The photosensitive element roll of the present invention is excellent in side wall flatness of a resist pattern, flatness on an upper surface of the same, resolution, adhesiveness, winding deviation during shipping, productivity and operatability, and having less number of mouse bites.

20 The process for preparing a resist pattern of the present invention is excellent in side wall flatness of a resist pattern, flatness on an upper surface of the same, resolution, adhesiveness, productivity and operatability, and having less number of mouse bites.

25 The resist pattern of the present invention is excellent in side wall flatness of a resist pattern, flatness on an upper surface of the same, resolution, adhesiveness, productivity and operatability, and having less number of mouse bites.

30 The resist pattern laminated substrate of the present invention is excellent in side wall flatness of a resist pattern, flatness on an upper surface of the same, resolution, adhesiveness, productivity and operatability, and having less number of mouse bites.

35 The process for preparing a wiring pattern of the present invention is excellent in side wall flatness of a resist pattern, electric resistance and appearance of lines.

The wiring pattern of the present invention is excellent



in side wall flatness of a resist pattern, electric resistance and appearance of lines.

1004050-12000

Claims

1. A photosensitive element comprising a support film which comprises a biaxially oriented polyester film and a  
5 photosensitive resin composition layer formed on one surface of the polyester film,

wherein a resin layer containing fine particles is formed on the opposite surface of the support film to which the photosensitive resin composition layer is formed, and said  
10 photosensitive resin composition comprises

(A) a binder polymer having a carboxyl group,  
(B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule,  
and

15 (C) a photopolymerization initiator.

2. A photosensitive element having a layer of a photosensitive resin composition on a support film, which comprises having a heat shrinkage ratio in the lateral direction of the support  
20 film at 200°C for 30 minutes being 0.00 to 4.00%, and said photosensitive resin composition comprises

(A) a binder polymer having a carboxyl group,  
(B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule,  
25 and

(C) a photopolymerization initiator.

3. The photosensitive element according to Claim 2, wherein the heat shrinkage ratio in the lateral direction of the support  
30 film at 150°C for 30 minutes is 0.00 to 0.20%.

4. The photosensitive element according to Claim 2, wherein the heat shrinkage ratio in the lateral direction of the support  
film at 105°C for 30 minutes is 0.00 to 0.20%.

5. A photosensitive element having a layer of a photosensitive

resin composition on a support film, which comprises having a heat shrinkage ratio in the lateral direction of the support film at 150°C for 30 minutes being 0.00 to 0.20%, and said photosensitive resin composition comprises

- 5 (A) a binder polymer having a carboxyl group,  
(B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and  
(C) a photopolymerization initiator.

10

6. The photosensitive element according to Claim 5, wherein the heat shrinkage ratio in the lateral direction of the support film at 105°C for 30 minutes is 0.00 to 0.20%.

- 15 7. A photosensitive element having a layer of a photosensitive resin composition on a support film, wherein a contact angle (°) of the support film with water satisfies the following numerical formula (1):

20 
$$\frac{(\text{Contact angle at X surface})}{(\text{Contact angle at Y surface})} > 1.1 \quad (1)$$
  
wherein X surface means a surface of the support film to which the photosensitive resin composition is coated and dried; and Y surface means a surface of the support film opposite to the surface to which the photosensitive resin composition is coated,

25

and said photosensitive resin composition comprises  
(A) a binder polymer having a carboxyl group,  
(B) a photopolymerizable compound having at least one polymerizable ethylenically unsaturated group in the molecule, and  
30 (C) a photopolymerization initiator.

35

8. The above photosensitive element according to Claim 2, wherein the support film is a support film comprising a resin layer containing fine particles being laminated on one surface of a biaxially oriented polyester film, and the photosensitive

resin composition layer is coated and dried on the opposite surface of the support film to which the resin layer is formed.

5 9. The photosensitive element according to Claim 1, wherein an average particle size of the fine particles is 0.01 to 5.0  $\mu\text{m}$ .

10 10. The photosensitive element according to Claim 1, wherein a thickness of the resin layer containing fine particles is 0.05 to 5.0  $\mu\text{m}$ .

11. The photosensitive element according to Claim 1, wherein a haze of the support film is 0.01 to 5.0%.

15 12. The photosensitive element according to Claim 1, wherein a heat shrinkage ratio in the longitudinal direction of the support film at 105°C for 30 minutes is 0.30 to 0.60%.

20 13. The photosensitive element according to Claim 1, wherein a heat shrinkage ratio in the longitudinal direction of the support film at 150°C for 30 minutes is 1.00 to 1.90%.

25 14. The photosensitive element according to Claim 1, wherein a heat shrinkage ratio in the longitudinal direction of the support film at 200°C for 30 minutes is 3.00 to 6.50%.

30 15. The photosensitive element according to Claim 1, wherein a weight average molecular weight of (A) the binder polymer having a carboxyl group is 20,000 to 300,000.

16. The photosensitive element according to Claim 1, wherein an acid value of (A) the binder polymer having a carboxyl group is 50 to 300 mg KOH/g.

35 17. The photosensitive element according to Claim 1, wherein (B) the photopolymerizable compound is a bisphenol A type

(meth)acrylate compound.

18. The photosensitive element according to Claim 1, wherein  
(C) the photopolymerization initiator is 2,4,5-triaryl  
5 imidazole dimer.

19. The photosensitive element according to Claim 1, wherein  
formulation amounts of Components (A), (B) and (C) are  
40 to 80 parts by weight of Component (A) based on 100 parts  
10 by weight of Component (A) and Component (B) in total,  
20 to 60 parts by weight of Component (B) based on 100 parts  
by weight of Component (A) and Component (B) in total, and  
0.01 to 20 parts by weight of Component (C) based on 100 parts  
by weight of Component (A) and Component (B) in total.

15 20. A photosensitive element roll according to any one of  
Claims 1 to 19, wherein the above photosensitive element is  
wound up or rolled around a core.

20 21. A photosensitive element roll in which the photosensitive  
element is wound up around a core, wherein a total height of  
winding deviation at the edge surface of the photosensitive  
element roll after naturally dropping the photosensitive  
25 element roll five times from the height of 10 cm to the collision  
surface so that the axis direction of the core becomes  
perpendicular to the collision surface is 1 mm or less.

22. A process for preparing a resist pattern which comprises  
laminating the photosensitive element according to any one of  
30 Claims 1 to 20 to a substrate for forming a circuit so that the  
photosensitive resin composition layer is closely contacted to  
the substrate, irradiating imagewisely active light to  
photocure the exposed portion, and removing an unexposed  
portion by development.

35 23. A resist pattern prepared by the preparation process

according to Claim 22.

24. A resist pattern in which unevenness on the side surface of the resist pattern is 0 to 3.0  $\mu\text{m}$ .

5

25. A resist pattern in which a number of unevenness larger than 3.0  $\mu\text{m}$  on the center line of the side surface of the resist pattern is 0 to 5/4 mm.

10 26. A resist pattern in which a mathematical average roughness ( $R_a$ ) on the side surface of the resist pattern is 0 to 2.0  $\mu\text{m}$ .

27. The resist pattern according to Claim 26, wherein a maximum height ( $R_y$ ) on the side surface of the resist pattern is 0 to 3.0  $\mu\text{m}$ .

15

28. A resist pattern comprising a maximum height ( $R_y$ ) on the side surface of the resist pattern of 0 to 3.0  $\mu\text{m}$ .

20 29. The resist pattern according to any one of Claims 24 to 28, wherein a width of the resist pattern is 1  $\mu\text{m}$  or more.

30. The resist pattern according to any one of Claims 24 to 28, wherein a height of the resist pattern is 1 to 150  $\mu\text{m}$ .

25

31. The resist pattern laminated substrate which comprises the resist pattern according to any one of Claims 24 to 28, wherein it is formed on a substrate for preparing a circuit.

30 32. A process for preparing a wiring pattern which comprises subjecting the resist pattern laminated substrate according to Claim 31 to etching or plating.

35 33. A wiring pattern prepared by the process for preparing the wiring pattern according to Claim 32.

34. A wiring pattern in which unevenness on the side surface of the wiring pattern is 0 to 3.0  $\mu\text{m}$ .
35. A wiring pattern in which a number of unevenness larger than 3.0  $\mu\text{m}$  on the center line of the side surface of the wiring pattern is 0 to 5/4 mm.
36. A wiring pattern in which a mathematical average roughness ( $R_a$ ) on the side surface of the wiring pattern is 0 to 2.0  $\mu\text{m}$ .
37. The wiring pattern according to Claim 36, wherein a maximum height ( $R_y$ ) on the side surface of the wiring pattern is 0 to 3.0  $\mu\text{m}$ .
38. A wiring pattern comprising a maximum height ( $R_y$ ) on the side surface of the wiring pattern of 0 to 3.0  $\mu\text{m}$ .
39. The wiring pattern according to any one of Claims 34 to 38, wherein a width of the wiring pattern is 1  $\mu\text{m}$  or more.
40. The wiring pattern according to any one of Claims 34 to 38, wherein a height of the wiring pattern is 0.01 to 200  $\mu\text{m}$ .

Fig. 1  
Axis direction

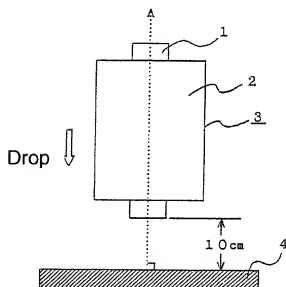


Fig. 2A  
Axis direction

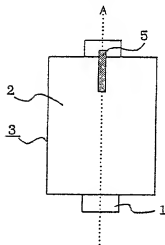


Fig. 2B  
Axis direction

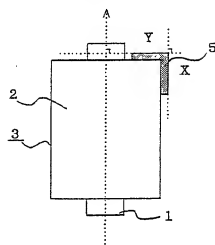


Fig. 3

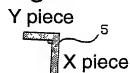




Fig. 4A  
Axis direction

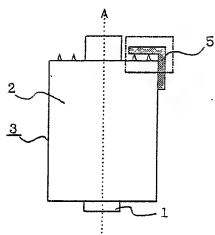


Fig. 4B

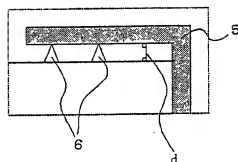


Fig. 5

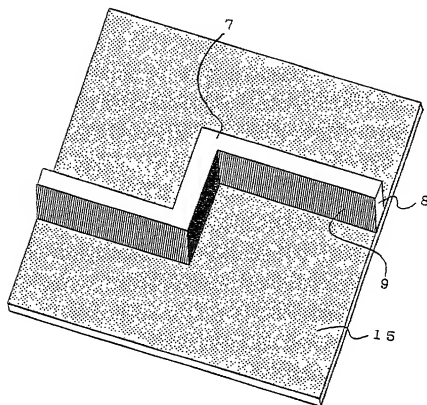


Fig. 6

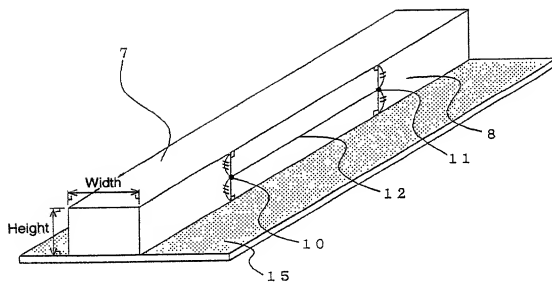


Fig. 7

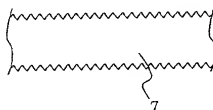
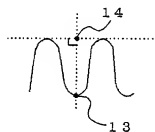


Fig. 8



Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

## Declaration and Power of Attorney For Patent Application

## 特許出願宣言書及び委任状

## Japanese Language Declaration

## 日本語宣言書

下の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私番号、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

**PHOTOSENSITIVE ELEMENT, PHOTOSENSITIVE ELEMENT ROLL, PROCESS FOR THE PREPARATION OF RESIST PATTERN USING THE SAME, RESIST PATTERN, RESIST PATTERN LAMINATED SUBSTRATE, PROCESS FOR THE PREPARATION OF WIRING PATTERN AND WIRING PATTERN**

上記発明の明細書（下記の欄でx印がついていない場合は、本表に添付）は、

the specification of which is attached hereto unless the following box is checked:

☐ 月 日に提出され、米国出願番号または特許協定条約国際出願番号を \_\_\_\_\_ とし、  
（該当する場合） \_\_\_\_\_ に訂正されました。

☒ was filed on 21/June/2000  
as United States Application Number or  
PCT International Application Number  
PCT/JP00/04028 and was amended on \_\_\_\_\_  
(if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則典第37編第1章56項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

# Japanese Language Declaration (日本語宣言書)

私は、米国法典第35編119条(a)-(d)項又は365条(b)項に基づき下記の、米国以外の国の少なくとも一カ国を指定している特許協力条約365条(a)項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

## Prior Foreign Application(s)

外国での先行出願

177587/1999  
 (Number)  
 (番号)  
 52990/2000  
 (Number)  
 (番号)

Japan

(Country)

(国名)

Japan

(Country)

(国名)

24/June/1999

(Day/Month/Year Filed)

(出願年月日)

29/February/2000

(Day/Month/Year Filed)

(出願年月日)

Priority Not Claimed

優先権主張なし

☐

☐

私、第35編米国法典119条(e)項に基づいて下記の米国特許出願規定に記載された権利をここに主張いたします。

(Application No.)

(出願番号)

(Filing Date)

(出願日)

(Application No.)

(出願番号)

(Filing Date)

(出願日)

私は、下記の米国法典第35編120条に基づいて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約365条(c)項に基づく権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第37編1.56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

(Application No.)

(出願番号)

(Filing Date)

(出願日)

(Status: Patented, Pending, Abandoned)

(現況: 特許許可済、係属中、放棄済)

(Application No.)

(出願番号)

(Filing Date)

(出願日)

(Status: Patented, Pending, Abandoned)

(現況: 特許許可済、係属中、放棄済)

私は、私自身の知識に基づいて本宣言書で私が行なう表明が真実であり、かつ私の入手した情報と私の信じていることに基づく表明が全て真実であると信じていること、さらに故意にされた虚偽の表明及びそれと同等の行為は米国法典第18編第1001条に基づき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の表明を行えば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Japanese Language Declaration  
(日本語宣言書)

委任状: 私は下記の発明者として、本出願に関する一切の  
手続を米特許商標局に対して遂行する弁護士または代理人  
として、下記の者を指名いたします。(弁護士、または代理  
人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint  
the following attorney(s) and/or agent(s) to prosecute this  
application and transact all business in the Patent and Trademark  
Office connected therewith (list name and registration number)

Joerg-Uwe Szimpl, Reg. No. 31,799 and B. Franklin Griffin, Jr., Reg. No. 19,334

書類送付先

Send Correspondence to:  
GRIFFIN & SZIMPL, PC  
Suite PH-1  
2300 Ninth Street, South  
Arlington, VA 22204  
Customer No. 24203

直接電話連絡先: (名前及び電話番号)

Direct Telephone Calls to: (name and telephone number)

Telephone: (703) 979-5700  
Facsimile: (703) 979-7429

第一発明者 日付	Full name of sole or first inventor	Tatsuo CHIBA
発明者の署名	Inventor's signature	Date 12/12/2001
住所	Residence	Hitachi-shi, Ibaraki, Japan
国籍	Citizenship	Japan JPY
私書箱	Post Office Address	2-5-104, Kokubu-cho 3-chome, Hitachi-shi, Ibaraki 316-0035 JAPAN
第二共同発明者 日付	Full name of second joint inventor, if any	Tatsuya ICHIKAWA
第二共同発明者の署名	Second inventor's signature	Date 12/12/2001
住所	Residence	Hitachi-shi, Ibaraki, Japan
国籍	Citizenship	Japan JPY
私書箱	Post Office Address	7-6, Higashinamikawa-cho 2-chome, Hitachi-shi, Ibaraki 317-0052 JAPAN

(第三以降の共同発明者についても同様に記載し、署名をす  
ること)

(Supply similar information and signature for third and subsequent  
joint inventors.)